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PRIMARY MALIGNANT TUMORS OF THE FOOT

A REPORT OF 37 CASES

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IN a period of nineteen years, during which time 10,459 cases of malignant disease were admitted to the Institute for study, we have been impressed with the relative infrequency of malignant tumors occurring in the foot. However, the frequency has been sufficiently striking to stimulate an interest in making an analysis of the various kinds of tumors which affect that member.

In reviewing the literature we find several contributions to the study of tumors of the foot. Treves (1) reported a case of sarcomatous tumor of the sole of the foot in 1887; Shedden (2), in 1888, a case of epithelioma of the sole of the foot, with metastases in the lymph nodes of the groin; Jessett (3), in 1889, an alveolar sarcoma of the foot. Langdon (4), in 1894, Caubet (5), in 1903, Morestin (6), in 1905, Hertzler and Gibson (7), in 1914, have contributed articles on melanotic tumors of the foot, the latter giving extensive case reports, with a discussion of the histogenesis of the tumor. Kurtz (8), in 1930, reported a pigmented mole of the sole of the foot resulting in melanotic sarcoma; Baldwin (9), in 1921, a case of chondro-sarcoma of the plantar surface of the foot.

Our records show that the most common malignant tumor of the foot is the melanotic sarcoma, or the so-called nevus cell carcinoma: 17 of the 37 cases fell into this category. Next in frequency were 8 cases of squamous-cell carcinoma of the skin; then, 6 cases of sarcoma of the soft tissues; 4 cases of bone sarcoma, 1 adenocarcinoma, and 1 basal-cell epithelioma of the skin of the foot.

Table I shows the location of the nevus cell carcinomas, the ages and sex, the history of duration, previous treatment, treatment at the Institute, and the result of treatment.

It will be observed that 10 of the 17 cases reported were lesions originating on the sole of the foot and heel and that they were nearly all far advanced, coming rather late for treatment. It would seem, after an analysis of these cases, that the only hope of circumventing the absolute mortality is to carefully scrutinize the feet in the yearly physical examinations, so that these pigmented nevi which are the precursors can be dealt with radically. After malignancy is apparent in this type of tumor it is usually too late for any form of treatment except palliation. Early, wide excision, and irradiation are undoubtedly of value, but it would seem that, if one is quite sure the disease is still local, amputation is the method of choice.

TABLE I

Age Sex	History of Duration	Previous Treatment	Location	Treatment at Institute	Result of Treatment
76 F	Ten months: pimple, which was irritated and grew larger	Excision of lesion	Sole of left foot involving arch, nodes in left inguinal region	Radium pack to foot and inguinal region	Lost trace of in three months; result undetermined
43 F	Nine months: arch swollen and painful; gradually became more swollen until drain was inserted	Drain inserted, inguinal nodes removed	Sole right foot, metastases in inguinal region and chest	High power x-ray	Died in one month. *Autopsy:* Nevus cell carcinoma, foot; metastases in retroperitoneal glands which had invaded the vertebræ; metastases in lungs
36 F	Two years: black spot on sole of foot size of quarter; pulled skin off	Excision of lesion one week previous to admission	Sole and outer side of left foot, 3-4 cm. in length	Unfiltered x-ray	Has not been observed since treatment
41 M	Fifteen years: blister, which developed into a growth	Excision of lesion one year 6 months previous to admission	Right heel, two inches in diameter	High power x-ray and unfiltered x-ray followed one year after admission by amputation of foot and dissection of inguinal glands	Died from general carcinomatosis two years and ten months after admission
70 F	Six months: dark area on heel which bleeds easily	None	Heel, right foot	Amputation right foot	Clinically well, died four years later from carcinoma of breast
69 M	Two years: small blister, which gradually increased in size; lesion was red but became black. Large node in inguinal region for one month	None	Outer side of right foot over os calcis; large metastasis in inguinal region; metastases to lungs	High power x-ray	Patient did not return to complete treatment as planned; died from metastases to lungs in five months
38 F	Six months: crack-like lesion which has grown gradually	None	Outer side of heel, 2 cm. in diameter; small nodes in inguinal region	Coagulation and excision; high power x-ray to foot and inguinal region; radium bomb and high power x-ray to recurrence	Clinically well following first treatment—then recurrence on foot and in inguinal regions; patient died one year and eleven months after admission (Fig. 1)

55 M	Six years: small growth back of right foot; doubled size in five years; one year ago began to grow rapidly; patient unable to wear shoe	None	Between external malleolar process and achilles tendon; 2-3 cm.	Excision of lesion; filtered, low-power x-ray	Clinically well two years four months; lost trace of case
27 M	Four months: injury to heel (bump); swelling and pain since	Excision one month previously	Outer side of left foot, tendon achilles	High power x-ray	Has not been observed since treatment
65 M	Seven years: pieces of coal would get into shoe, causing irritation; lesion never healed and gradually grew larger; considerable pain	None	Right heel; very dark ulcerating lesion; metastases in inguinal region, mediastinum, and lung	High power x-ray over foot and inguinal region	Died in eight months from general carcinomatosis (Fig. 2)
56 M	Two years: stepped on nail; foot was sore but healed; year and one-half previously wart-like lesion appeared	Excision and cautery	Inner side of right foot over instep; nodes in both inguinal regions	Radium plaques and high power x-ray to foot and inguinal regions	Eight months since admission; still thickening at site of lesion
64 M	Twelve years: sore spot on foot, which grew gradually until six weeks ago, when it broke open and began to bleed. (Lesion accidentally cut three times since first noticed.)	None	Outer side of left foot; posterior half at site of pigmented mole; numerous nodules over leg and thigh, inguinal region, along aorta, infiltration of lung	High power x-ray	Died in one month (Figs. 3 and 4)
40 F	One year: mole on inner side of foot, which blistered and opened; five months ago noticed hard fixed node in groin	Excision of lesion and inguinal node	Inner side of foot; metastases in inguinal region	Excision of recurrence and resection of inguinal nodes	Died in one year and four months from metastases all over skin and in brain; no recurrence of original lesion
64 M	Five years: brown spot which blistered and broke open; grew gradually	Excision three years previously	Outer side of left foot; large nodes in inguinal glands	High power x-ray and unfiltered x-ray	Died in one year from multiple metastases; original lesion unimproved
64 M	Two months: sore appeared, apparently caused by tight shoes	Coagulation	Right side of foot; hard nodes in right inguinal region; small nodes in left inguinal region	High power x-ray	Still under treatment
47 M	Eight months: toe became sore; four months later growth was noticed in groin	Excision of lesion and inguinal nodes	Under big toe nail; nodes in inguinal region	Radium seeds to lesion and radium pack to inguinal nodes	Died in seven months from general carcinomatosis
69 F	One year: callus on foot was trimmed off; broke open and grew	Excision of lesion	End of fourth toe; metastases in leg, thigh, and inguinal region	High power x-ray	Ten months since admission; metastases still palpable

Ewing (10) reviews the theories of the origin of melanoma, quoting Ribbert, Masson, and others. He recommends the adoption of Masson's theory as the most comprehensive yet evolved, that "melanoma arises from portions of the entire end-apparatus of the sensory nerve filaments of the skin."

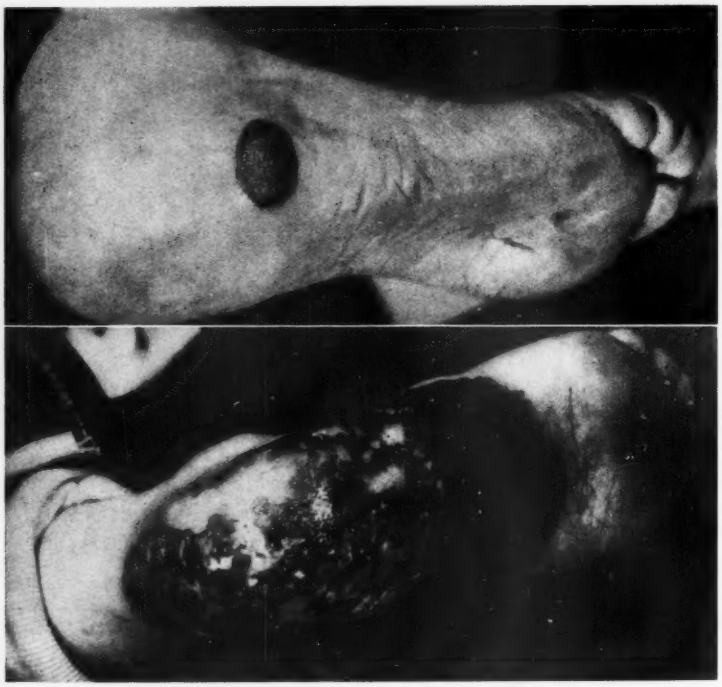

Fig. 1 *(above)*. Showing small nevus-cell carcinoma with no evidence of metastases when patient was admitted; causing death from general metastases in one year, eleven months.

Fig. 2 *(below)*. Nevus-cell carcinoma of the heel.

Of the eight squamous-cell epitheliomas, one was an epithelioma of the instep which began as a callus from a shoelace in a man 65 years of age. This was treated by radium and x-rays. The patient died two years after admission of intercurrent disease—the lesion had improved but not healed.

One originated over the inner side of the heel at the site of an injury with a sledge hammer 25 years previously. This man, 80 years of age, was treated with unfiltered and high power x-ray. The foot healed but the metastases in the groin progressed, causing death two years and four months after admission.

One, in a male 62 years of age, was a lesion 2.5 inches in diameter on the outer part of the right foot, with metastases in the groin. It had been growing for ten years. The leg was amputated at the middle third, the groin was treated with high power x-ray, and the patient has been well for over five years (Fig. 5).

In one, a growth on the right little toe was noticed two years previous to admission, at which time it was excised and treated with x-ray. Two months before admission the growth was again excised and the nodes in the groin resected. On admis-

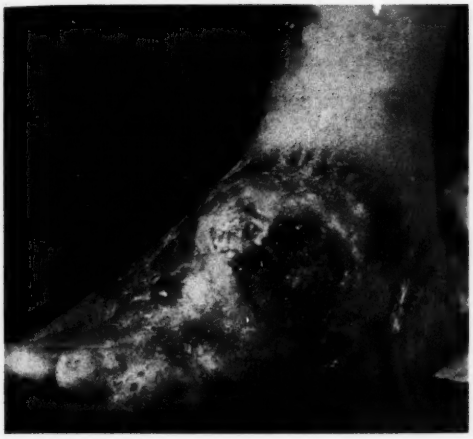

Fig. 3. Far-advanced nevus-cell carcinoma of the foot, with metastases (cf. Fig. 4).

sion, the original lesion was well but there were metastases in the groin. These were treated with radium, but the patient died in three months. There had been no recurrence of the original lesion at the time of death.

One originated in a scar where the anterior half of the foot had been accidentally amputated fifty-six years before. This patient refused treatment.

Three of these lesions occurred on the sole of the foot; two of them at a site where calluses had been treated by x-ray several years before. Both of these patients were women, 48 years of age; in one, the lesion had existed for two years before admission. She is being treated with high power x-ray over the foot and groins and the lesion is improving. The other patient was treated with radium packs until the leg was amputated (Fig. 6) because of tendon involvement. The third lesion originated at the under-surface of the fourth toe, the site of a corn, and on admission involved the fourth and fifth toes, together with the dorsum and sole of the foot. This lesion, in a man 65 years of age, was treated with high power x-ray, but he died in five months. Autopsy revealed no metastases.

Both of the cases which had been treated

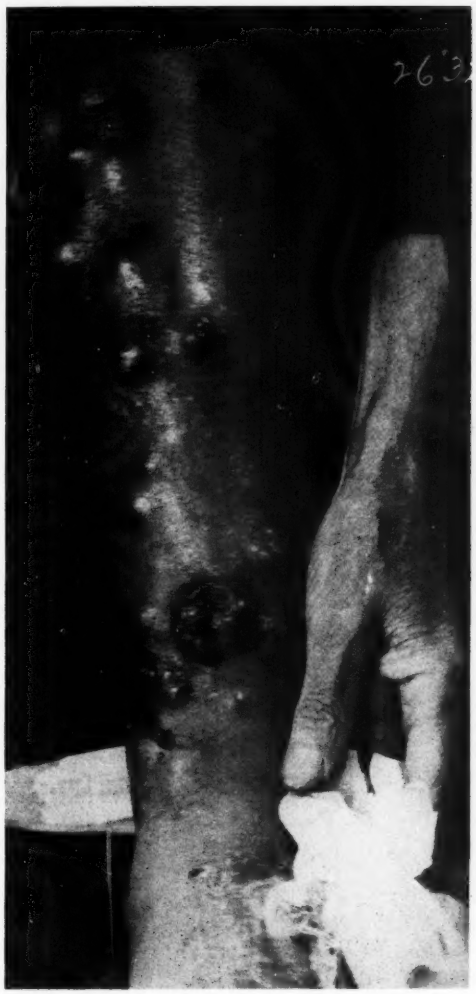

Fig. 4. Same case as in Fig. 3, showing metastases in the leg, also metastases in the thigh, groins, along the aorta, and in the lungs.

for apparently benign lesions showed some evidence of x-ray dermatitis, with malignant degeneration, when admitted. These two cases are of especial interest as they call attention to the fact that treatment of plantar warts by irradiation should not be overdone; that, if after a reasonable treatment with the x-ray, the plantar warts have not been eradicated, it is much wiser to resort to some other form of therapy.

Treatment of the squamous or pearl epi-

Fig. 5. Squamous-cell epithelioma of the foot, clinically well five years following amputation.

thelioma should be by irradiation if the lesion is superficial, not involving the tendons or bones. If extensive ulcerations and infiltrations have occurred, resort should be had to amputation.

One of the sarcomas in the soft tissues of the foot, in a woman 51 years of age, on the right foot between the fourth and little toes, began four months previous to admission when a cow stepped on the patient's foot. An abscess formed, then healed, but a lump appeared soon after, which biopsy showed to be a myxosarcoma. It was treated with high power x-ray, after which the lesion seemed to be well for a year and two months, when it recurred. It was again given high power x-ray and the lesion remained stationary for a year and eight months. It was then treated with radium and high power x-ray and has been well for the past two years, now almost seven years since admission (Fig. 7).

Two of the sarcomas in the soft tissues of the foot were fibrosarcomas, one of which, in a male 37 years of age, on the inner surface of the left heel, was 4 cm. in diameter. There were marked metastatic nodes in the left inguinal region. The tumor mass had existed one year previous to admission, following an injury to the foot. The lesion had been excised before admission, and, while the patient was treated here with high power x-ray, he died in six months from the metastases, the original lesion remaining well. The other fibrosarcoma was in a male 28 years of age who had noticed a sore and swelling for one year previous to admission. The lesion was an ulcer on the dorsal surface of the right foot 5 cm. in diameter. This patient was treated with high power x-ray and was clinically well for

Fig. 6. Squamous-cell epithelioma of the sole of the foot following x-ray treatment for a plantar wart.

two years preceding his death from intercurrent disease (Fig. 8).

Another sarcoma in the soft tissues was a sarcocarcinoma, in places an adenocarcinoma, and in still other places resembling a spindle-cell sarcoma. The lesion occurred in a male 24 years of age, and had existed five years previous to admission, appearing as a swelling which followed an injury caused by dropping a sharp plank on his foot. This swelling grew gradually until nine months before admission, after which it grew rapidly. It was excised one week before admission. The scar was treated with low power filtered x-ray and had appeared clinically well for a year and ten months when there was a recurrence. Three years after admission lung metastases developed and the patient died, the lesion on the foot not having healed at the time of death.

One was a spindle-cell sarcoma, with giant cells over the left instep, occurring in a male aged 28. It had begun four years previous to admission, when a piece of iron fell on the foot. The growth at first was the size of a pea but increased rapidly, especially during the preceding two years. The lesion had been excised two weeks prior to admission and he was treated at the Institute with radium packs. The lesion had not recurred at the time we lost trace of the patient.

One was a myeloid tumor in a female 25 years of age which began as a pimple under the large toe nail a year previous to admission, and increased to the size of the end of the little finger. This was removed two weeks before admission and given high power x-ray at the Institute. The patient has been well for over seven years.

One of the bone sarcomas was an osteogenetic sarcoma in a girl 19 years of age. On admission, there was rarefaction of the os calcis, which was scraped out. Diagnosis at that time was spindle-cell sarcoma. She

Fig. 7. Myxosarcoma of the foot.

was treated by means of irradiation over the foot, and the cavity in the bone practically healed out and remained well for four years. Then a bluish-looking tumor developed in the scar over the skin of the foot which was irritated by her shoe. This grew with a sudden rapidity, necessitating amputation of the leg. She died from general metastases to the lungs and viscera eight years, five months after admission. Various pathologists expressed the opinion that this tumor showed the histology of an osteogenic tumor which had destroyed several of the small bones of the foot.

Another case was an osteogenic sarcoma in a boy 17 years of age which originated in the os calcis. This patient died two years after admission, with extensive metastases.

Another case was an osteochondrosarcoma in a woman 34 years of age which originated in the large toe. The patient has been well five years since the removal of the tumor and treatment by x-ray.

The other case was that of a tumor, consisting of spindle and giant cells, in a man 32 years of age, which originated in the first metatarsal bone. He was treated by operation, curettage of the bone, and irradiation, and has been well six years since treatment.

The basal-cell epithelioma occurred on the sole of the foot, near the heel, in a woman

63 years of age, and resulted, she said, from an injury caused by a nail in her shoe. The lesion was treated with radium and is now well.

The one case of adenocarcinoma, in a man

Fig. 8 *(left)*. Fibrosarcoma of the instep, well after irradiation.
Fig. 9 *(right)*. Adenocarcinoma of the skin of the foot.

32 years of age, was apparently primary in the skin of the foot, involving the anterior and inner surface of the ankle, with a history of irritation from the shoe. This lesion was biopsied and treated with x-rays but the patient died from generalized metastases six months after admission (Fig. 9).

CONCLUSIONS

1. A review of our records shows nevus-cell carcinoma (melanosarcoma) to be the most common malignant neoplasm occurring on the foot.

2. The treatment of nevus-cell carcinoma is very unsatisfactory. Earlier diagnosis is essential in the hope that radical treatment may be instituted before the spread of this growth.

3. Squamous-cell epithelioma is the malignant tumor next in frequency, occurring on the foot. This can be healed, if taken early, by irradiation. If extensive, amputation is a life-saving measure.

4. Attention is called to the two cases developing malignancy after treatment by irradiation for apparently benign lesions of the sole of the foot.

5. Basal-cell epithelioma and adenocarcinoma of the skin of the foot are rare.

6. Six sarcomas of the soft tissues were observed.

7. Only four primary bone sarcomas were observed.

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ROENTGEN TREATMENT OF BENIGN AND MALIGNANT LESIONS OF PROSTATE[1]

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IN the first place, it is not possible clinically to distinguish different kinds of carcinoma in the prostate gland. All prostatic cancers are adenocarcinomatous, consisting usually of a number of gland-like structures lined with cells, in either a single or a double row, smaller than normal acini. with no intra-acinous projections, and usually packed closely together. The cells themselves often can not be distinguished from normal cells, though they may be a little larger or smaller than normal. Mitotic figures in prostatic carcinoma are rarely found: now and then one meets with an intra-acinous carcinoma, in which type the proliferation of tumor cells is within an acinus. Most striking is the invasion of the dilated acini of cystic hypertrophy, which produce large masses of tumor cells, so that on occasion such a tumor may take on an almost papillary structure. In later development the growths take on a frankly infiltrating form and no longer depend on the formation of new acini or on growth within acini already formed. There may be thick or thin strands or masses of carcinoma cells invading surrounding structures. If the fibrous tissue reaction around the tumor is marked, a so-called scirrhous cancer is produced.

The outstanding clinical characteristic of cancer of the prostate is stony hardness—the one factor which makes diagnosis possible, and without which the diagnosis is almost never made. This hardness is in proportion to the amount of fibrous tissue reaction in and around the tumor, and in cases of intra-acinous carcinoma in which no fibrous stroma has been laid down and before infiltration has occurred, or in fast-growing infiltrative tumors, the cancer may be soft to the touch. In the usual form the induration is marked and most evident in the posterior (rectal) surface, because the posterior lobe, or the subcervical glands, is the most frequent site of origin. In the usual hard, indurated form of cancer, surfaces made by cutting are smooth and do not bulge. Prostatic cancer is gray in color, studded or streaked with yellow opaque

[1]Read before the Radiological Society of North America at the Eighteenth Annual Meeting, at Atlantic City, Nov. 28–Dec. 1, 1932.

material—the gray is fibrous tissue; the yellow, the strands or nests of tumor cells.

METASTASIS OF PROSTATIC CARCINOMA

The prostate and prostatic area are drained by three sets of lymphatics, the one group running laterally to the nodes around the external iliac artery, a posterior group which ascends laterally to the rectum on either side and empties into the presacral nodes near the internal iliac artery, and a central group which drains also the seminal vesicles and enters nodes as high as the bifurcation of the aorta. Any or all of these nodes may be secondarily involved and are accountable for such symptoms as pain in the legs due to pressure on the sacral plexus of nerves or edema of the legs following compression of the veins.

Metastasis to bony structures is not surprising to any roentgenologist, and can be accounted for only by spread through the blood stream. Skin nodules and nodules in the liver and other organs have been definitely traced to blood metastasis. The seminal vesicles, bladder wall, corpora cavernosa, and urethra are often involved by direct extension.

Carcinoma of the prostate is rare before 40 years of age. Young, Bumpus, and Deming agree that 45 to 50 per cent of all cases of carcinoma of the prostate occur in men between the ages of 60 to 70, about 20 per cent occur in the decade before 60, and 20 per cent in the decade after 70 years.

Authors vary on the percentage of prostates causing obstruction which are found to be malignant, but taking a mean of these figures roughly leads us to the conclusion that 20 per cent of men over 60 years of age will have symptoms of prostatic trouble, and 20 per cent of these will have cancer; in other words, four men in every hundred who live to be 60 years of age will have cancer of the prostate.

The period of time which elapses between the onset of cancer and the beginning of symptoms is not known. However, knowing that, in most cases, the progress after diagnosis is made is not rapid, one can assume that the cancer has been present for some time, perhaps years, before the patient presents himself to the doctor. For this reason we advocate a rectal palpation as a part of every physical examination in a man of cancer age.

Diagnosis and Symptoms.—The symptoms of prostatic carcinoma are usually those of vesicle neck obstruction, that is—frequency of urination, nocturia, difficulty of urination, and pain. Most often frequency and difficulty are the first symptoms, though we have seen two cases in which the only symptom was pain in the back and perineum. Cases are reported in which the initial symptom was hematuria or acute retention of urine, and we have seen both of these conditions as primary symptoms. Bone metastasis, skin nodules, or a palpable abdominal mass has been recorded as the first inkling of a prostatic tumor. Such cases, however, are rare. The urinary symptoms are by far the most common and are due either to constriction of the prostatic urethra or to a coincident benign prostatic hypertrophy. Benign hypertrophy occurs in association with about 60 per cent of prostatic carcinomas.

The principal means of establishing a diagnosis is the rectal examination. Induration is the most important feature. In typical cases this induration is great (described as "stony hard") and the prostate is fixed. The hardness may extend to the seminal vesicles or to the intervesicular angle, while occasionally the rectal wall itself may be involved. In a typical case the surface of the induration is irregular or nodular. When benign hypertrophy is present, it may obscure the carcinoma. Prostatitis combined with tuberculosis of the prostate, a very rare condition, sometimes causes an induration which is hard to distinguish from carcinoma, and true prostatic

stones form nodules which feel very much like cancer. We have seen large prostatic stones which could be distinguished from cancer of the prostate only by x-ray examination.

Modes of Treatment.—Carcinoma of the prostate has been treated in various ways—radium applied to the prostate by means of rectal applicators and urethral applicators, needles of radium inserted into the carcinoma either through the perineum or the bladder surface *via* a cystotomy opening, or radium emanation seeds applied in like manner.

Radical removal of the prostate, seminal vesicles, and prostatic urethra has also been done with some success in early cases. In 1912 one of us (L. E. S.) made the statement that when a diagnosis of carcinoma of the prostate can be made by rectal examination, it is too late for successful surgical removal. The statement was condemned at the time as being a hindrance to surgery, but it is now accepted universally.

X-ray Therapy.—The importance and value to the patient of deep x-ray therapy in carcinoma of the prostate has been a subject of considerable discussion during the past ten years. Writers on the subject vary greatly in their opinions, the consensus being that it is of some value.

Smith and Peirson (1) agree that some cases are materially benefited by deep x-ray therapy, while Hugh Young (2) says that its chief value lies in relief from pain. In 1928 Barringer (3) considered x-ray therapy of great value, but we understand that since then he has practically discarded its use in prostatic cancer. Mann (4) states that alleviation of symptoms occurs almost as infrequently as cures, and is only temporary. Morton (5) reports improvement in many cases in both local and general condition of the patient.

The way in which x-radiation influences deep-seated cancer of the prostate is much discussed in the literature, the consensus of opinion being that the benefits are derived from two sources: (1) Actual injury to and destruction of the tumor cells; (2) the formation of fibrous tissue about the tumor.

It is difficult to estimate accurately the value of x-ray therapy, no means of measuring its effectiveness being available. However, in this report, (1) effect upon pain, (2) effect upon extent of primary growth, (3) effect upon the general condition of the patient will be used as gauges.

Here 12 cases are used for comparison, all of which have received x-ray treatment under similar conditions. None of them had other forms of treatment, such as removal of the gland, punch operations, radium, etc. Some of them had suprapubic cystotomies done to relieve urinary symptoms. None of the cases treated with the x-ray as a preventive measure following prostatectomy in which the pathologic tissue revealed a small cancer are used in this report. All of these cases are from the private practice of one of us (L. E. S.) and the diagnoses were made by him.

In the preparation of this report we have purposely avoided using the word "cure," since it is not our intention to try to convey to the profession that we can cure these patients. Our only reason for preparing this report is to bring again to the attention of our colleagues the value of the x-rays in combating the pain and other symptoms which invalid these patients, for we are convinced that much help can be given by the judicious use of them.[2]

We are reporting only these 12 cases because many of our otherwise eligible patients have had other forms of treatment such as surgery and radium, or have not been checked closely by competent urologists. This series comprises for the most part patients treated within the last three

[2]As a radiologist I am not basing this opinion on my own observations but on the judgment of my colleagues who have watched these patients carefully and have at frequent intervals examined them. Before and after each series of roentgen treatments the patient is carefully scrutinized by Dr. Schmidt and Dr. Grauer.—E. L. J.

years, though two were treated during 1925. At no time during the last three years have we felt that our roentgen technic was entirely satisfactory. From time to time we have changed our x-ray factors and also our method of administration. During the early period of the work we used rather low filtration and gave the treatment within a comparatively short period of time. We were informed by our physicist that it was not necessary to go beyond 0.5 mm. of copper filter; in fact, he thought—like many others—that this amount of filter (0.5 mm. copper) was the optimum and that beyond this point filtration became uneconomical and nothing was gained. In the light of our later experience we are convinced that much better results can be obtained by using higher filtration and by spreading the series over a longer period of time. It is our opinion that less damage is done to the surrounding normal tissues by highly filtered x-rays, given over a long period of time in divided doses, than when using lower filtration and delivering the dosage within a short period of time, or the so-called "intensive irradiation."

At present we are giving consideration to increasing the time consumed in administering the required dose. When we first attempted this work we used 0.5 mm. of copper, and even when we gave up to 600 r through each of three portals we did not obtain the improvement which followed in later cases using from 1 to 1.25 mm. of copper. It is true, we caused quite definite tanning of the skin, which we do not produce with our present technic, but the changes in the prostate were not in proportion to the amount of x-ray energy absorbed in the skin.

It seems to us the method of Regaud (6) as used by Martin (7) in radium application also applies to the administration of the roentgen rays. They have reported excellent results in treating malignancies by small doses of heavily filtered radium, the dose required consuming many days. It is their opinion that the surrounding normal tissues are not damaged to the extent that they are when intensive doses are given, using only a moderate amount of filtration.

It is believed by many radiologists and physicists that rays of very short wave length and high penetrating power have a greater selectivity for radioresponsive cells and are less prone to cause necrosis. There are also other advantages in decreasing the intensity, such as increasing the selectivity of radiosensitive cells by prolonging the time of exposure, or administration. The margin of safety for normal tissues is also increased, while the malignant tissues are made to regress even in tumors which are quite radioresistant to low intensities.

In treating prostatic malignancies we do a routine x-ray examination of the bones of the pelvis, such a film record being of importance both from a diagnostic standpoint and for future comparisons.

The presence of metastasis in the bones of the pelvis does not eliminate the possibility of roentgentherapy, nor does it mean that no help can be given the patient. In one case of our series definite evidence of bone metastasis was present in the x-ray film, while in another the changes in the bones were certainly suggestive of metastasis. In neither case did we advise against therapy, although we informed the patients that we were not over-enthusiastic about the possibility of the treatment giving them much relief. Both were treated with high voltage, using heavy filtration, during the last part of 1930 and the early part of 1931. They were greatly improved when last examined by Dr. Schmidt and are at present carrying on their daily duties.

When Dr. Schmidt last examined Case 1 (showed definite x-ray evidence of pelvic bone metastasis) he found the prostate much smaller—no areas of hardness could be felt on deep or superficial pressure, nor could any nodules be felt. Dr. Schmidt made the

following note: "There is no resemblance between the rectal findings now and on the first examination. The patient is free of pain, his stream is normal ('good as it was twenty years ago'), he has no urinary symptoms, and his weight and general health are very satisfactory."

Case 2, with x-ray findings suggestive of pelvic bone metastasis, when last examined by Dr. Schmidt showed the following on rectal examination: "Prostate is soft and smooth except for the upper right lobe, which is nodular and stony hard. The irregular hard area extends upward into the region of the vesicles and seems larger than on the previous examination. Subjective findings: No pain; nocturia decreased from three to one; no frequency. Patient says he feels perfectly well."

These two patients are referred to here to show the benefit which may be given even though metastasis is present. We know, or, at least, feel, quite sure these patients will eventually die from the cancer, but they have at least been given new hope and are free of distressing symptoms and are changed from invalids into useful citizens.

From the above reports we do not wish to convey the idea that all our cases have reacted favorably; on the contrary, some of them did not show marked improvement in the physical findings, and, likewise, there was no amelioration of symptoms. We are not able to state why some patients have failed to respond unless we venture the opinion that the factors we used in administering the treatment were not properly determined. By this, we mean that our filtration may have been inadequate and the absorption of the rays took place in the skin and superficial tissues, with insufficient irradiation to the deeper structures. We are convinced that since we have increased our filtration and divided our dosage, consuming a longer period of time in giving the series, our results have improved.

From the rectal examination of the prostate by means of palpation it is impossible to determine in advance the patients who will respond favorably and those who will not. In all our cases the prostate, or at least a portion, has been stony hard. Contrary to what might be expected, the cases with the very hard extensive involvement of the prostate, with fixation, have done exceedingly well with our revised form of treatment. In one patient in particular the stony hard prostate has been completely absorbed, and on Sept. 19, 1932, Dr. Schmidt reported the rectal findings to be negative for carcinoma.

Method of Treatment.—At present we are using 200 K.V.P. 1.25 mm. of copper plus 1 mm. of aluminum, at a distance of 50 cm. With these factors we are delivering 6.5 R.P.M. measured in air, computed with a Mecapion (Victoreen) and a roentgenometer. The latter is always in position, giving a constant reading. The treatment is directed through three portals, *i.e.*, anterior pelvis (directed downward at the prostate area, 20×20 cm.); perineum (the patient sitting on the opening, using a couch, treating from below); posterior field, directed downward at the prostate. These portals are treated for a period of about ten days and then the patient is allowed to rest for a period of six weeks. We administer approximately from 1,800 to 2,400 r to the three portals measured in air, during the period of treatment. The depth dose with our present technic is about 50 per cent at 10 cm., which, using the present factors, delivers around 2,400 r to the three portals. We do not obtain any skin changes and we can repeat the dose safely in six weeks. Recently we have been using the Thoraeus filter (0.25 mm. Cu plus 0.2 Sn plus 1 mm. Al) which delivers about the same intensity to the skin in r as 1 mm. of copper, but delivers a wave length equivalent to 2 mm. of copper. The filter does not lengthen the time factor but gives a much shorter wave length, filtering out most of the long waves.

This filter has not yet been used long enough to enable us to say definitely what advantages it offers.

We are not disposed to be over-enthusiastic about our permanent results and, as far as increasing the lives of these patients, possibly we have not accomplished a great deal over the older method. We do feel, however, that the greater percentage of this group has been helped, taking the symptoms of pain and nocturia as criteria. The patients have not been made to suffer the added discomforts which usually follow prostatectomy and, also, they have been able to go about their usual daily routine and are able to sleep through the night.

From this series of 12 cases one can summarize by saying that seven patients have died, four of them without any apparent benefit from x-ray therapy. Two of those who died showed improvement in the rectal findings and were relieved of pain by x-ray therapy. One patient had relief from urinary symptoms and definite improvement of the rectal findings, but died of leukemia two years after the diagnosis of carcinoma of the prostate was made. The five patients who are still living have all had relief of pain and improvement in their urinary symptoms. Their general health and weight have been maintained and their rectal findings have been influenced for the better.

Taking the above figures as a basis for determining the value of the x-rays in this small but carefully supervised series, we arrive at the following: 33⅓ per cent of the patients received no benefit from the treatment; 25 per cent received definite benefit and improved, but later died; 40⅔ per cent have been greatly improved objectively and subjectively and are still living.

CASE REPORTS

Five cases may be cited in some detail, since they are typical of the series.

Case 1. This patient, aged 66 years, entered the hospital Dec. 24, 1929, complaining of painless hematuria which had been present for two months and of a low lumbar pain of an aching nature which had been present for four months. He had no other urinary symptoms.

The general physical examination was negative. On rectal examination there was observed a diffuse, broad, very firm prostate, the left lobe being more firm and larger than the right. The prostate was fixed and, high up on the left, gave a nodular impression.

Cystoscopy revealed a markedly elongated prostatic urethra over the left half of the vesicle neck and extending into the trigone, and, bordering the bladder, there was an elevated mass—somewhat irregular and showing small necrotic areas.

Diagnosis was made of a carcinoma of the prostate with extension into the bladder.

The nitrogen constituents of the blood were normal: hemoglobin 72 per cent; red blood cells 3,960,000; white blood cells 8,200. The urine showed 30 mg. of albumin, microscopic and macroscopic blood, with large amount of pus. Blood pressure was 190/114.

On Jan. 2, 1930, one course of x-ray therapy was given and the patient was discharged from the hospital. In February, 1930, he had another course of four treatments. For three months after this the patient felt fine; had no pain or hematuria. Six months later (June 4, 1930) he re-entered the hospital, complaining of a marked frequency both day and night, with considerable bleeding at times during the past month. Rectal examination revealed a massive infiltration of the prostate, vesicles, and palpable portion of the bladder. The periaortic lymph nodes could be palpated. The liver was enlarged and felt nodular. On June 11 a suprapubic cystotomy was done to relieve the intense urinary symptoms. The patient died on June 16 from post-operative cardiac failure.

Case 2. This patient, aged 83 years, had a prostatectomy performed in 1914 for a simple benign hypertrophy and, on pathologic examination, no carcinoma was found. Fifteen years later (in 1929), the patient presented himself again, this time because of a recurrence of his urinary symptoms. He complained of frequency and nocturia (every two to three

hours). The stream had gotten smaller in the last six months. He also stated that there was pain most of the time in the region of the sacrum. He had lost no weight. The general health was exceptionally good for a man of his age.

Examination revealed nothing of importance. Rectally the prostatic capsule felt firm, extending from pelvic wall to pelvic wall; no urethral groove could be felt. There was an area in the right side, extending up into the right vesicular region, as large as the last phalanx of the thumb, which was stony hard, nodular, and irregular.

The nitrogen constituents in the blood were normal; hemoglobin was 78 per cent; red blood cells, 3,890,000; white blood cells, 7,050; blood pressure, 136/80.

The patient returned for examination April 22, 1930, at which time he was having difficulty in urinating and suffered suprapubic pain when the bladder became full. His urinary symptoms had increased markedly in the intervening six months, and the infiltration of the prostate had extended markedly—now the entire gland was hard and nodular.

A suprapubic cystotomy, with subsequent x-ray treatment, was advised and carried out. A permanent suprapubic fistula was made on April 26, 1930, and eight courses of x-ray treatment given between April 29, 1930, and November 7, 1931.

The patient got along well and the pain was gone entirely. His weight was maintained and the gland was reduced in size and became considerably softer on monthly examinations during this period until July, 1932. Then the patient began to complain of edema of both legs, cough, and shortness of breath due to cardiac decompensation. He was put on cardiac management and was better for a time, but then grew steadily weaker and died on September 8, 1932.

In this case x-ray therapy seems to have controlled the size of the gland and did improve the pain and maintained the patient in good health for over two years. How much of his terminal condition may have resulted from metastatic growth is unknown; however, none was demonstrated.

Case 3. The patient, aged 73 years, upon examination Oct. 16, 1930, stated that for the past two years he had been getting up two or three times at night to urinate and that he urinated every two hours during the day. For the previous few days he had noticed a discomfort in the rectum on sitting down and some pain was present in the sacral region most of the time; otherwise his health was good.

Examination revealed an enlarged heart, with a mild presystolic murmur. The heart was well compensated, however. Otherwise the general examination was satisfactory.

Rectal examination showed the prostate to be irregular, the right lobe larger than the left. The right lobe was nodular and hard, as was also the posterior isthmus.

Hemoglobin was 90 per cent; red blood cells, 4,780,000; white blood cells, 5,800; blood pressure 146/108.

The urine was negative for albumin and sugar. Microscopically a few pus cells were seen and an occasional red blood cell and hyaline cast.

The diagnosis was carcinoma of the prostate, and x-ray treatments were begun. Three and a half courses were given, between November, 1930, and June, 1931. The patient was examined regularly at intervals of two months. On Sept. 16, 1931, he was in general good health, and had had no pain since the previous winter. Night urinations were cut down from three times to one time, and he suffered no frequency. The rectal findings were much improved. The infiltration in the right lobe had reduced to about one-half its size of a year before. The last examination was Oct. 17, 1932. The general health and weight have remained the same. The man feels perfectly well—has no pain of any kind. Following a ten-day motor trip he had some increased frequency of urination. Blood and urine findings were about the same as at the first examination. The prostate at this time is soft and smooth except for the upper right lobe, which is nodular and stony hard. This irregularity extends upward into the region of the vesicles and seems to be larger than at the time of the previous examination.

Case 4. The patient, aged 65 years, consulted a doctor Dec. 4, 1931, because of slight increase in frequency of urination and nocturia. He stated that formerly he had been up one or two times each night, but during the past few months this had increased to three times. There was also difficulty in starting to urinate and slight suprapubic pain. He had had migraine headaches for many years and during the past six years had had frequent attacks of angina pectoris. His weight has remained stationary for many years.

On general physical examination the heart was found to be slightly enlarged to the left and there was some roughening of the second aortic tone. The lungs were clear. There was slight tenderness along the ascending colon. The bladder was not palpable suprapubically. Rectally the examiner found a moderately large prostate, the left lobe larger than the right. The urethral groove was shallow. The consistency of the right lobe was normal, while the left lobe was stony hard, and irregular in the upper portion, this infiltration extending into the region of the left seminal vesicle.

Hemoglobin was 88 per cent; red blood cells, 4,490,000; white blood cells, 6,400; blood pressure 156/104. The urine was clear, without albumin or sugar. Microscopically a small amount of pus was seen and an occasional red blood cell. A diagnosis of carcinoma was made and x-ray therapy advised. This was carried out in seven courses, from Dec. 17, 1930, to August, 1932.

Rectal examinations made during the first year showed the mass to be decreasing in size and becoming much softer. On Nov. 17, 1931, no sign of the infiltration could be found on rectal examination. The patient had no complaints to make; the urinary symptoms had improved; there was a nocturia of one time and no difficulty in starting; there was no pain, and his weight had been maintained.

The last examination was made on Sept. 19, 1932, at which time rectal findings were negative for carcinoma. There has been no return of his pain or urinary symptoms. He still has occasional attacks of angina pectoris. His weight and general health are unchanged

Case 5. This patient, aged 66 years, was first seen April 16, 1931, complaining of pain in the upper portion of the left leg. The pain had been persistently present for three months and a slowing of the urinary stream had been present for six months. He had no frequency of urination or nocturia. Because of this pain an x-ray film of the pelvis had been taken a few days before, which showed changes in the left ischium, which the radiologist thought were suspicious of metastasis in this bone. The patient had lost no weight or strength and felt fine in every way except for this pain.

General physical examination was negative in all essentials. Rectally, there was a collar-shaped hypertrophy of the prostate extending from pelvic wall to pelvic wall, partly protruding into the rectum, smooth and rounded. On deep palpation there was a sensation of marked hardness. Superficially there were three hard nodules in the right upper lobe.

Hemoglobin was 80 per cent; red blood cells, 4,060,000; white blood cells, 7,900; blood pressure, 134/76. The urine showed no albumin, no casts, and on microscopic examination was found to be normal.

Two courses of x-ray therapy were given between April 20, 1931, and July 26, 1931.

At examination on Sept. 17, 1931, the patient reported that, after the first course of x-ray treatment had been given, he had complete and almost immediate relief from his pain and had had no pain since. His stream at this time is as good as it was twenty years before and he has no urinary symptoms. The weight and general health are fine. Rectally, the prostate in general is much smaller, no hardness can be felt on deep or superficial pressure, and no nodules of any kind are palpable. There is no resemblance between the rectal findings now and those on first examination. The patient has since moved away and contact with him has been lost.

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PULMONARY TUBERCULOSIS[1]

THE ROENTGENOLOGIC APPLICATION OF A CLINICAL CLASSIFICATION

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THE classification which I shall present to-day is the clinical classification of pulmonary tuberculosis recently described by Ornstein, Ulmar, and Dittler (1, 2). For the past year I have witnessed the application of this classification clinically at Sea View Hospital. Because of its general usefulness and simplicity, I wish to submit it to you from the roentgenologic standpoint.

The increased use of surgery in pulmonary tuberculosis demands an adequate classification, particularly if the surgical results are to be of value. At the present time, the results of the various surgical procedures, reported from different parts of the country, show wide differences. This cannot be attributed to surgical technic, but to improper interpretation of the pathology of tuberculosis. The National Tuberculosis Classification depends upon the size or quantity of the lesion, paying no attention to the quality of the pathology.

All cases of pulmonary tuberculosis, excluding the primary infection, may be divided into two groups: the acute inflammatory and the chronic productive. The acute inflammatory group is subdivided into three types: the benign exudative, the exudative-productive, and the caseous-pneumonic.

[1]Read before the Radiological Society of North America, at the Eighteenth Annual Meeting, at Atlantic City, Nov. 28–Dec. 1, 1932.

It is generally agreed that we receive our primary infection during infancy or childhood, from which we recover and develop a certain immunity. The result of a superinfection depends upon the dosage and virulence of tubercle bacilli coupled with the allergic response of the host. A marked allergic response to a number of tubercle bacilli results in the exudative form of pulmonary tuberculosis. When the dosage is somewhat greater, the exudative-productive type of pulmonary tuberculosis follows. A massive dose of tubercle bacilli with a marked allergic response results in the caseous-pneumonic type. A small dose of tubercle bacilli, with little or no allergic response, ushers in the chronic productive type of pulmonary tuberculosis.

1. *Exudative, or Benign Acute, Type of Pulmonary Tuberculosis.*—This type is an acute lesion. Because the symptoms are few and not alarming it is very often overlooked. The symptoms, which are no more marked than an ordinary cold, disappear in a few days. Hemoptysis occurs in about 40 per cent of the cases. Tubercle bacilli are found only at the onset, while there is expectoration. Inasmuch as cough and expectoration quickly subside, it is difficult to demonstrate tubercle bacilli except during the first few weeks of the disease.

The pathology is not definitely known, but

it resembles the so-called gelatinous pneumonia. This lesion shows a serous exudate, little fibrin, and few cellular elements. There is no tissue injury. With this type of pathology, one can readily understand how simple it is for resolution to occur without leaving any traces.

The roentgenologic findings are more alarming than the clinical symptoms. The film shows an area of diminished aeration, varying in size from a small patch to a lobe or lung, of uniform density, resembling an area of consolidation. The exudative cases all do well. Complete resolution occurs in a period varying from six weeks to six months, leaving no traces of the lesion in the roentgenogram. During irregular resolution of the lesion, annular shadows, which may be mistaken for cavities, are often seen.

Using the National Tuberculosis Classification, an exudative lesion, depending upon the extent of pathology, can be characterized as far advanced, and, to the amazement of all, will completely resolve. There is no objection to using the various stages indicating the extent of the lesion, but one must identify its nature. A far advanced or Stage 3 exudative lesion has an excellent prognosis.

2. *Exudative-productive Type of Pulmonary Tuberculosis.*—In this type of tuberculosis the reaction is more severe than in the exudative type, due to a larger dosage of tubercle bacilli. The lung shows very little tissue injury, a serous exudate, fibrin, a great deal of cellular elements and some productive changes. In this form resolution is also possible, leaving very little trace of the original pathology in the form of some fibrotic strands with small areas of productive changes. Small areas of caseation may exist, so small that they are not visualized on the roentgenogram.

The roentgenologic findings at first may be similar to the exudative type. The extent of the lesion varies. Resolution is much slower than in the exudative type, because of the increased amount of fibrin and cellular elements—it may take as long as from twelve to eighteen months for it to be complete. When resolution is complete, one usually finds a few small areas of productive changes in association with some fibrotic strands.

The prognosis in this type of pulmonary tuberculosis is good. The course of the disease is usually benign.

3. *Caseous-pneumonic Type of Pulmonary Tuberculosis.*—The pathologic picture in this form differs radically from the first two inflammatory types. A severe reaction, with a caseation necrosis, is the sequence; with the sloughing out of the caseating areas, cavities are formed which usually serve as a constant source of tubercle bacilli. Superinfections are common in this type, and the response may vary with each infection. At times this may occur repeatedly as an acinous exudative spread which will resolve completely, leaving no traces in the roentgenogram. Then again, the response may be either exudative-productive, caseous-pneumonic, or productive, depending upon the dosage. In the caseous-pneumonic type of tuberculosis one sees a retraction of the chest and lung, with distortion of the trachea and mediastinal structures. The prognosis in this type of tuberculosis is poor—over 50 per cent of the non-surgically treated cases die in the first year.

At the onset the roentgen appearances may be similar to the exudative lesion—an area of consolidation of variable extent. The lesion caseates and cavities present themselves, while areas of atelectasis, varying in size, are usually present. Fibrotic changes appear, either concomitantly with the caseation or after the inflammatory lesion has broken down and its substance expectorated.

Depending upon the extent and type of

the involvement, many manifestations of this form of pulmonary tuberculosis may be present: in fact, all the stages from exudation to necrosis may occur. Secondary changes due to and including atelectasis, fibrosis, and emphysema, with the attending deformation of the thoracic and mediastinal structures, with responses from superinfection, may all be present in any one case. The terminal stage of this lesion, when lobar, usually shows a markedly retracted lobe of the lung, a retracted chest wall, a marked deviation of the trachea and mediastinal contents to the affected side. Smaller lesions do not distort the mediastinal contents. The terminal stage of this type of pulmonary tuberculosis is the one which has fallen heir to many descriptive terms, which represent only a cross-section at a given time, or one stage of a caseous-pneumonic lesion.

4. *Chronic Productive Type of Pulmonary Tuberculosis.*—Quoting Ornstein and his co-workers:

"If the superinfecting dose is small and the allergic reaction slight, then a low-grade proliferative response is the result. According to Aschoff, this process starts in the bronchial tree at the junction of the terminal bronchiolus with the bronchiolus respiratorius. The lumen of the tube is soon occluded. When this occurs, there is an absorption of air in the alveolar sacs, with the result that the pulmonary acinus becomes atelectatic and shrinks down to a small nodule around the proliferative focus. This constitutes the so-called '*acinondose* type' of tuberculosis of Aschoff. It is the result of small superinfecting doses in a relatively non-allergic tissue. When adjacent acini are involved, the lung grossly assumes a cirrhotic, scarred appearance. It is a type of process which, because of its avascularity, is apt to give relatively few symptoms. The patient may have very few complaints, and may present himself only because of some complication, such as emphysema, or laryngeal or intestinal involvement."

The roentgen examination shows small nodules and fibrous tissue strands or interstitial changes. The lesion usually starts in the apex and gradually involves the adjacent lung—many years pass before extensive involvement is evident. These individuals are well, are not incapacitated, and the lesion may not be recognized for many years; as a rule, it does not prevent the individual from carrying on. As the lesion progresses and becomes more extensive, the nodules may coalesce, caseate, and form numerous small cavities resembling bronchiectatic dilatations. The chief complaint is usually dyspnea due to the accompanying emphysema.

Complications need not be considered now, for they do not in any way alter the use of this clinical classification. Acute miliary tuberculosis does not enter into the classification, for its development is an accident, a rupture of a tuberculous focus with a spread by means of lymph or blood. The true chronic miliary tuberculosis is rare and belongs to the chronic productive group.

I have already mentioned healing manifestations in adult type tuberculous lesions by resolution and fibrosis: healing by calcification has not been our experience in adult type pulmonary tuberculosis. Serial studies in many cases of superinfection have failed to show evidences of healing by calcification. During the primary infection and soon thereafter one encounters calcification. The numerous small calcareous foci often seen in one or both lungs are not healed superinfections, but probably the end-results of the primary infection.

In dividing pulmonary tuberculosis into four types, it is not to be assumed that these are pure types. The predominating lesion indicates the type, and the presence of cavitation always means caseous-pneumonic type. All four types may be present in any one case. At no time is there a transition from one form into another. Each type is caused by an independent reaction to a

tuberculous antigen. In one individual, when the dose is small, the response may be an exudative reaction, and on the next reinfection the response may be caseous-pneumonic. The exudative lesion never becomes caseous-pneumonic, and the caseous-pneumonic never becomes an exudative type lesion.

The picture presented gives only a rough and sketchy description of the classification, the real value of which lies in the ease and certainty with which you are able to select your cases for collapse therapy. With the increase of collapse therapy measures, proper selection of cases is essential, rather than the indiscriminate application of procedures in cases in which no such therapy is indicated. A haphazard selection of cases results in erroneous statistics. It must be remembered that this classification groups the cases from a clinical and roentgenologic standpoint, selects the cases which require collapse therapy measures, and incidentally gives you an opportunity to prognosticate in all types of pulmonary tuberculosis. Collapse therapy in pulmonary tuberculosis is a recognized procedure, the application of which is helpful and curative in some cases and unnecessary in others. Without the aid of the roentgenogram, the clinician cannot tell which cases require collapse therapy. If statistics in tuberculosis are to be of value, it is necessary that the clinician and the roentgenologist, as well as the thoracic surgeon, get together, speak and understand a common language. This will result in the abolition of collapse therapy procedures in cases in which they are not needed.

To recapitulate, the roentgenogram is an adjunct necessary to the phthisiologist, frequent roentgen examinations being necessary in all cases of pulmonary tuberculosis. Serial studies of all types of tuberculosis will permit of the division into the four types as described. Unless cavitation is present, it is difficult to differentiate early the inflammatory types of tuberculosis on a single roentgen examination. One should remember that all annular shadows are not cavities.

SUMMARY

Cases of pulmonary tuberculosis clinically and roentgenologically can be divided into two large groups, the acute inflammatory and the chronic productive groups. The first group is further subdivided into the exudative, the exudative-productive, and the caseous-pneumonic types, the two former benign, the latter malignant. Each group is readily recognized in the roentgenogram, particularly if serial studies have been made. This grouping of the cases from a clinical standpoint refers only to superinfection, and does not include the lesion attending the primary infection.

About 40 per cent of all cases of pulmonary tuberculosis are in the caseous-pneumonic group. With but few exceptions, this is the only group in which collapse therapy measures are necessary.

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THE EFFECT OF ROENTGEN RAYS ON THE TIME OF THE FIRST CLEAVAGE IN MARINE INVERTEBRATE EGGS

II. DIFFERENTIAL RECOVERY AND ITS INFLUENCE WHEN DIFFERENT METHODS OF EXPOSURE ARE USED[1]

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A RESPONSE in marine invertebrate eggs to x-rays presents for examination certain questions dealing with the effects of radiation on organisms and tissues. In a study of this response we have been concerned to learn something of the irradiation effect as a function of the circumstances which may govern its expression. We have considered separately (1) the production of the effect and (2) recovery from the effect. In a previous report (Henshaw, 1932) it was shown that development in the eggs of the sea urchin, *Arbacia punctulata,* is delayed when exposed to x-rays before fertilization, and further, that recovery takes place following irradiation. At this time we wish to review the previous work briefly, extend it, and compare it with similar effects produced in other organisms. Since recovery may influence differential irradiation effects obtained in tissues when different methods of exposure are used, we wish to discuss some of the influences when the time-factor in exposure is varied and when the saturation method of exposure is used, based on experimental data.

(A) Irradiation Effect.—The time intervening between the moment of fertilization and the onset of the first cleavage is noticeably prolonged when the eggs of Arbacia are exposed to certain doses of x-rays before fertilization. The *delay*, or what may be called *irradiation effect*, is the time required for cleavage in the irradiated eggs over and above that required for controls or non-irradiated eggs. The amount of irradiation effect produced in each case was found to depend upon the amount of radiation administered.

(B) Recovery. — While carrying out numerous experiments to determine the conditions under which the irradiation effect could be produced, it was found that the amount of delay caused was not only a function of the quantity of radiation given but also of the time intervening between irradiation and insemination of the egg samples. In other words, the effect was less marked if time elapsed between exposure and measurement of the effect. To illustrate, if a sample of eggs was irradiated and divided into two parts, one of which was inseminated at once and the other at a subsequent time, the latter invariably showed less irradiation effect. Thus it was found that recovery took place.

(C) Former Results.—In Figure 1 are plotted the data for one of the experiments presented previously.[2] The abscissa shows time in minutes from the moment irradiation ended, and the ordinate the effect in minutes of cleavage delay (semi-logarithmic scale). The curves, therefore, show the effect at any time after irradiation for different amounts of exposure. Parallel straight line curves have been drawn through the experimental points which fit about as well as any that could be drawn. The curves, sloping downward, show the loss of irradiation effect, or recovery. If parallel straight line curves actually charac-

[1]Part I—Recovery from X-ray Effects in *Arbacia Eggs.* Am. Jour. Roentgenol. and Rad. Ther., 1931, XXVII, 890-898.

[2]Similar results have been obtained during two other spawning seasons since these data were obtained.

terize the recovery process here, certain things are evident about the rate at which it takes place. First, it is constant (straight line curves on a semi-logarithmic scale) and second, it is the same for any degree of effect produced (parallel curves). Whether this specific condition characterizes the process, can be established fully only by extensive experimentation; since the data fit so well, however, it may be used as a close approximation, if not an exact description, of the process.

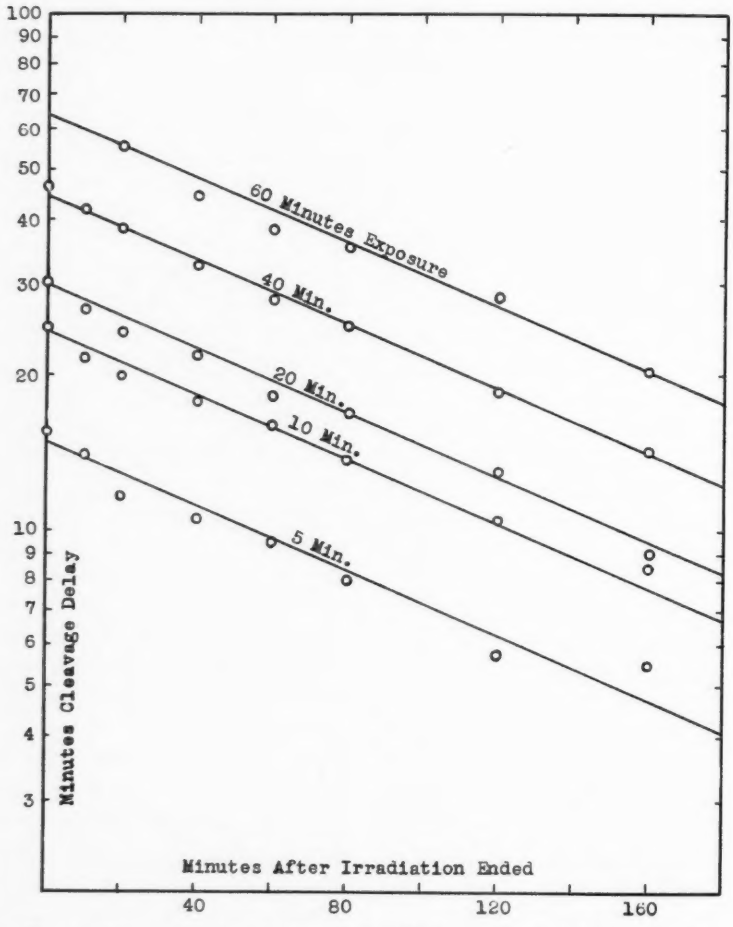

Fig. 1. Curves showing the loss of irradiation effect in Arbacia eggs after receiving different amounts of exposure (semi-logarithmic scale). From Henshaw, 1932.

Although the curves in Figure 1 show that recovery takes place, they do not show when it begins, a point of importance for certain considerations. As indicated in Figure 1, recovery is in progress immediately after irradiation and at the same rate in each case, whether the exposure has been of 5 minutes or of 60 minutes duration. Thus it would seem that the effect produced during the first 5 minutes in the sample receiving 60 minutes' exposure would have recovered during the next 55 minutes in the same way as did the effect produced in the sample which received only

5 minutes' exposure.[3] Similarly, it would appear that recovery began as soon as any effect was produced and that the effect was increased only by being produced faster than recovery took place. To determine whether or not recovery actually took place during exposure a special experiment was performed; by this, it was found that if the duration of exposure was prolonged eight times, dosage remaining the same, the effect was definitely less (20 to 40 per cent). Thus, in cases in which the exposure time was longer, part of the effect was lost. From this, it is evident that recovery did take place during exposure.

(D) Effect as a Function of Dosage.— In an attempt to follow the complete reaction it is desirable to plot the effect as a function of dosage. Data for such a plotting are at hand by referring to Figure 1 and taking, for instance, the values indicated by the curves intersecting the ordinate axis. These values show the degree of effect obtained with different exposures when determined immediately after irradiation, and have been plotted in Figure 2, Curve A.[4] Such a curve will be called an *effect curve*, to distinguish it from the *recovery curves* already discussed. Since recovery has been shown to occur during exposure, it is clear that the effect curve would be modified by this factor. Also, it is clear that recovery during exposure has caused the curves in Figure 1 to lie closer to the abscissa and closer to each other than they otherwise would.[5] In order to understand the nature of the effect curve better it was obtained by another method.

A large collection of eggs was obtained, prepared for irradiation, and divided into several parts. These were placed at different distances from the source of radiation and all were exposed for the same length of time (90 minutes); also, all were inseminated at the same time at the end of irradiation. The intensity of radiation which resulted from varying the distance from the source, caused the various samples to receive different quantities of radiation. Hence, the time during which recovery could take place while irradiation was going on was the same for all samples. The results for a sample experiment are shown in Figure 2, Curve B.

By comparing Curves A and B, certain things may be designated. Curve A has a point of maximum curvature near the beginning, a characteristic which appeared invariably in a series of experiments carried out for the express purpose of determining whether this was an artefact.[6] Curve B, on the other hand, shows a more gradual rise. That Curves A and B should be different is significant in view of the fact that the methods of treatment in each case differed only in duration of exposure.

For Curve A the samples were irradiated for different lengths of time. Accordingly, since the intensity of radiation was kept constant during the entire exposure and since (according to Figure 1) the rate of recovery appears to be the same for any degree of effect produced, relatively less recovery must occur in those samples receiving the shorter exposures. For Curve B,

[3] The procedure followed in the experiments was as follows: A large collection of eggs was obtained and carefully prepared for exposure. These were placed under the x-ray tube and exposure was begun at once. At intervals of 0, 5, 10, 20, 40, and 60 minutes samples were removed. Upon removal, each was further divided into eight parts, one of which was inseminated immediately and the others in turn at intervals of 10, 20, 40, 60, 80, 120, and 160 minutes after the first. For further information on procedure, measurement of effect, etc., see Henshaw, 1932.

[4] It should be borne in mind that the curves in Figure 1, because of their specific character, have the same relationship to each other throughout. Curve A, Figure 2, would accordingly have the same shape no matter from what point along the abscissa in Figure 1 the values are taken, when expressed on a percentage basis.

[5] In the previous report, the abscissa in some of the figures showed "minutes after irradiation *began*" rather than "minutes after irradiation *ended*," as is the case here. Such a plotting spread the curves apart in accordance with the duration of exposure in each case. It had the effect of moving them bodily to the right, the ones for the longest exposures being moved the farthest. It is obvious that the adjustment was only an approximation. Since, however, the plotting seemed more nearly the actual condition and since only the slope and shape of the curves were being discussed then, it was used. It should be noted that moving the curves bodily up or down or to the right or left, does not change their shape or slope.

[6] These experiments were performed by irradiating a collection of eggs, removing samples after receiving different intervals of exposure, and inseminating at once upon removal, a procedure essentially the same as that used in determining Curve A.

recovery must be relatively the same in each sample since all were irradiated for the same length of time. By superimposing Curve A on Curve B (see broken line curve, Figure 2), the data are seen to support this thesis.

ing to that shown in Figure 1, have been attached, which indicate the residual effect at different times after exposure when certain degrees of effect have been produced.[7]

With the aid of Figure 3 it is possible to

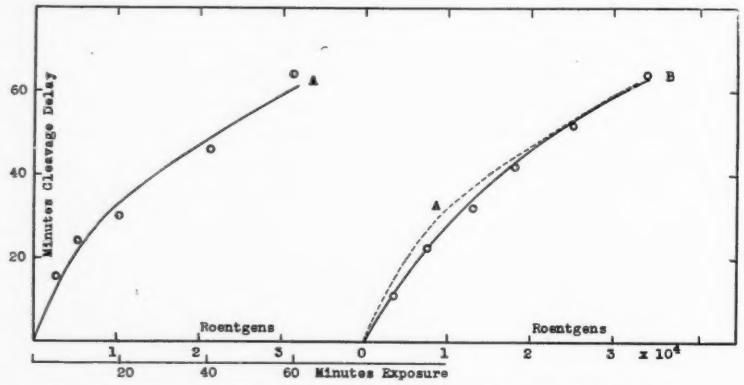

Fig. 2. Curves showing irradiation effect as a function of dosage.

As seen, the curves differ mainly in those parts determined by the smaller doses, the parts which received the greatest difference in duration of exposure in the two cases. The samples used for Curve A, which received the shorter exposures, actually show greater irradiation effects for equal doses. It seems, therefore, that the greater curvature of Curve A may be accounted for by saying that less recovery took place in those samples receiving the shorter exposures.

(E) Effect and Recovery Curves Joined.—Thus far we have considered independently recovery following irradiation and the production of the irradiation effect under certain conditions. Since recovery is a function of time and the irradiation effect a function of dosage, which can be expressed in terms of time, both can be plotted together on the same scale. Effect Curve A, being determined in terms of time, was plotted as shown in Figure 3, where the abscissa gives time in minutes from the moment irradiation began and the ordinate irradiation effect in minutes cleavage delay. Recovery curves, having slopes corresponding follow the complete process. Radiation is administered and a certain irradiation effect, cleavage delay, is produced as a result; then, beginning immediately, the effect becomes less, apparently following the logarithmic curve as a function of time.

(F) Cleavage Delay in Other Marine Invertebrate Eggs.—Having found that cleavage is retarded by irradiation and that recovery begins at once after exposure in one form of invertebrate eggs, it is of interest to investigate the same processes in other forms. For this the eggs of *Chætopterous pergamentaceus, Nereis limbata,* and *Cumingia telenoides* were used. The experimental procedure was the same as that used for Arbacia. Eggs were exposed to the radiation and the resulting delay (when present) was measured at different intervals after irradiation. The variety of mortality and cleavage delay effects observed was striking, but can be mentioned only briefly

[7]In case of the actual experiment, the whole figure would be shifted to the right by an amount corresponding to the normal cleavage time, a factor which, so far as we know, is a constant and does not modify the irradiation effect in any way.

here. For Chætopterous, the lethal dose (around 50,000 roentgens) was given without producing a change in cleavage time. Delay was caused in Nereis eggs but the lethal dose was so low (around 7,000 roentgens) that the effect could not be investigated to any extent.

In Cumingia eggs, however, cleavage delay was produced in much the same way as in Arbacia eggs; hence, it was possible to test this material for recovery. A number of such tests were performed but no evidence for recovery was found. Thus, recovery from the same irradiation effect produced in two similar forms does not take place in the same way, a relationship which may be spoken of as *differential recovery*.

The effect curve for Cumingia eggs is a straight line (see Fig. 4), which indicates that the effect obtained is proportional to the amount of radiation given. It is significant that, in cases in which recovery was found not to take place following irradiation, the curve obtained should have this shape. It suggests that the irradiation effect produced in Arbacia eggs is proportional to the amount of radiation given, but that the recovery factor acting during exposure causes the observant effect to be less as the time of exposure is increased.

(G) Differential Recovery and the Time Factor in Irradiation.—Having found that recovery takes place during irradiation in one form and not in another, it appeared that the *amount of differential effect* might be controlled by regulating the duration of exposure. The following experiment was performed.

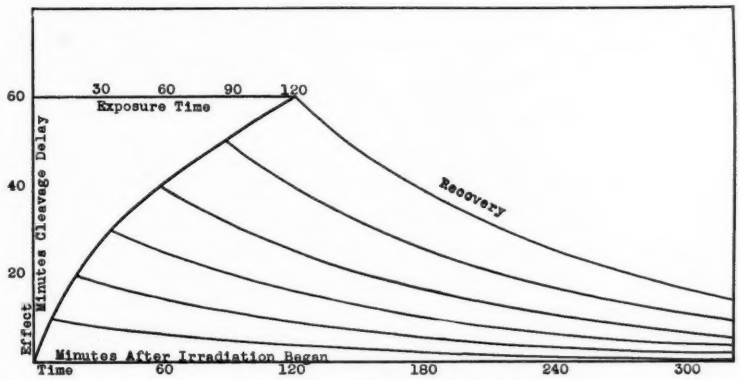

Fig. 3. Figure showing how the irradiation effect is produced as a function of time, intensity of radiation remaining constant, and how recovery proceeds when various degrees of effect have been produced.

Three samples of each type of eggs were prepared for irradiation. One of each was taken to the source of radiation and placed at a considerable distance from the tube where the intensity of radiation was low. Exposure was begun at once and lasted 150 minutes. A second pair of samples was irradiated during the last 30 minutes of this period but at a distance where it received as much radiation in 30 minutes as the first pair received in 150 minutes. All samples, including the third pair as controls, were inseminated at the end of irradiation and the amount of cleavage delay was determined. The results obtained are shown in Table I.

For Cumingia eggs equal amounts of radiation, whether administered over a longer or shorter period of time, produced approximately the same effect. For Arbacia, however, the effect was markedly less in the sample which received the longer exposure. The percentage relationships obtained with

the two methods of exposure are shown in parentheses.

It should be stated that considerable variation in results was obtained for different experiments, due mainly to the experimental

TABLE I

	Irradiation Effect in Minutes Cleavage Delay	
Exposure	Arbacia	Cumingia
30 min.	21 (100)	11.5 (100)
150 min.	12 (57)	12.5 (108)

procedure used. In considering the influence of the time factor it was important to have as widely different exposure times as possible for the two intensities of radiation used and at the same time make the duration of the higher intensity exposure as short as possible to keep the experiment from becoming cumbersome and uncontrollable. Thus by shortening the duration of exposure the maximum irradiation effect obtained was made small. Accordingly, the percentage experimental variation was large. Despite this, however, the results tended definitely to show the effect indicated by Table I.

The experiment illustrates how it is possible to control the amount of differential effect obtained by regulating the duration of exposure. If Arbacia eggs are to be spared and the Cumingia eggs destroyed, the exposure should be spread over a long period of time. This allows recovery to take place in Arbacia eggs so that the tolerance dose is not reached and exceeded as would be the case in Cumingia eggs, in which no recovery takes place. On the other hand, if Arbacia eggs are to be destroyed and the Cumingia eggs spared, the best results will be obtained by using very high intensities, for Arbacia eggs are more radiosensitive when recovery is not allowed to take place.

In clinical radiotherapy the same principles may apply. Suppose, for instance, that the normal tissues behaved like Arbacia eggs and the diseased tissue which is to be destroyed like Cumingia eggs, favorable results would be obtained only when the exposure was extended over a long period of time. Conversely, if normal tissues behaved like Cumingia eggs and the diseased tissue like Arbacia eggs, the most favorable results would be obtained with shorter exposures. It should be clear, therefore, that *the duration of exposure which will give the most favorable results depends upon the relative rates of recovery in the tissues irradiated.*

There are cases on record indicating that better clinical results have been obtained when low intensities and long exposures were used.[8] It is suggested that this may be due to the conditions of recovery in the tissues involved rather than to the conditions of mitotic rate, as has been suggested previously.

(H) Differential Recovery and the Saturation Method of Exposure.—The idea that recovery from irradiation effects takes place in organisms in a definite way is not new. Barr and Bovie (1923) found in irradiating Amebæ with ultra-violet light that more irradiation was required to produce cytolysis and death when divided doses were used. Kingery (1920), in studying the skin erythema, found also that more radiation could be given by allowing time for recovery. He suggested that recovery probably varies directly with the rate of disappearance of a hypothetical photochemical product. For certain work he assumed that the degree of effect was dependent upon the concentration of such a substance and that recovery followed a logarithmic curve. The rate of recovery in the skin was determined by finding how long it was necessary to wait after a full erythema dose had been given before an additional half erythema dose could be given without producing an additional effect. This was found to be three and one-half days. Then by adjusting a logarithmic curve to pass through this point he was able

[8] See Regaud, C., and Ferroux, R.: Strahlentherapie, 1929, XXXI, 495, and Juul, J.: Acta Radiologica, 1930, XI, 226.

to predict how much residual effect was present at any time and what fraction of an erythema dose would be required to bring the effect up to 100 per cent, or to "saturation." Kingery's curves, reproduced here (Fig. 5), illustrate this process. They indicate that half an erythema dose must be given every three and one-half days in order to maintain the effect (erythema) at 100 per cent, or that three-fourths of an erythema dose must be given every seven days.

Pfahler (1926) and others have employed the saturation method in the treatment of tumors, assuming that the important thing was to *get in* more radiation. As a rule, however, discussions dealing with the saturation method have not considered recovery in the diseased tissue. It should be clear that if recovery takes place in the tumor tissue as rapidly as it does in the normal tissues, no advantage would be gained by using the saturation method of exposure instead of the massive dose method. Whether an advantage will be gained depends specifically upon the relative rates of recovery in the tissues concerned. The diagram, Figure 6, makes this clear. Suppose three irradiation effects are produced, one of which recovers 25 per cent, another 50 per cent, and the other 75 per cent in a period of three and one-half days. Then, if recovery follows the logarithmic curve in each case and if saturation is maintained in the one which recovers 50 per cent in the specified interval, the effect for the other two responses would mount and fall as shown by the broken and dotted line curves, respectively. Thus it is seen that added effect is obtained only in the irradiation response which recovers more slowly than the one maintained at saturation. For this reason it is essential to know the relative rates of recovery for skin (normal tissues in general) and diseased tissue in order to know whether better results will be obtained by using the saturation method in radiotherapy. So far as we are aware, no attempt has been made to determine the relative rates of recovery from irradiation effects produced in tissues; there is only the inference which can be drawn from Pfahler's clinical observations. He has reported that more favorable results were obtained in cancer therapy when the saturation method was used; this being true, it follows that recovery in the tumor tissues must have been slower than in the normal tissues.

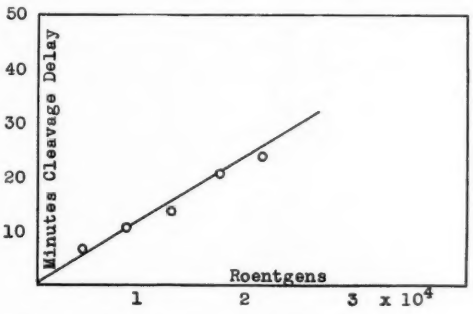

Fig. 4. Curve showing irradiation effect as a function of dosage for Cumingia eggs.

There are on record a number of experiments presenting results obtained with divided doses of radiation. Some indicate that the same effect is obtained whether the dose is divided or given all at once. Notable among these are the following: Spear (1931), observing the damaging effects of radiation on tissue cultures of choroid and sclera of fowl; Patterson (1931), observing mutation rate in Drosophila; and Ancel and Vintemberger (1925), observing destructive effects produced on hens' eggs before incubation. More, however, have observed that less effect was obtained when divided doses were given: Ancel and Vintemberger (1925), observing destruction in hens' eggs after incubation began; Ancel and Vintemberger (1928), observing destructive effects on *Rana fusca;* Ancel (1928), measuring linear growth in lentil roots; Crowther, observing mortality in the protozoan Colpidium, and Arntzen and Krebs (1925), observing growth reduction in Pisum plantlets.

These experiments are mentioned in support of the idea that recovery may or may not take place after irradiation. This should encourage the investigation of recovery in marine invertebrate eggs can be measured at different times after irradiation, the persistence of an irradiation effect in living material could be studied.

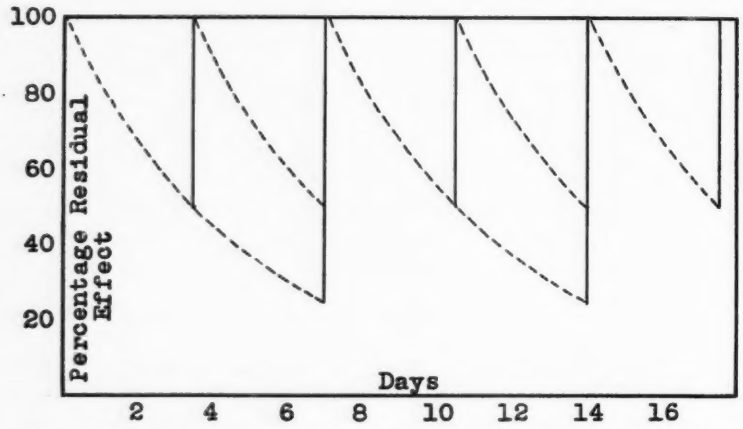

Fig. 5. Kingery's curves showing the maintenance of saturation of a certain effect in human skin.

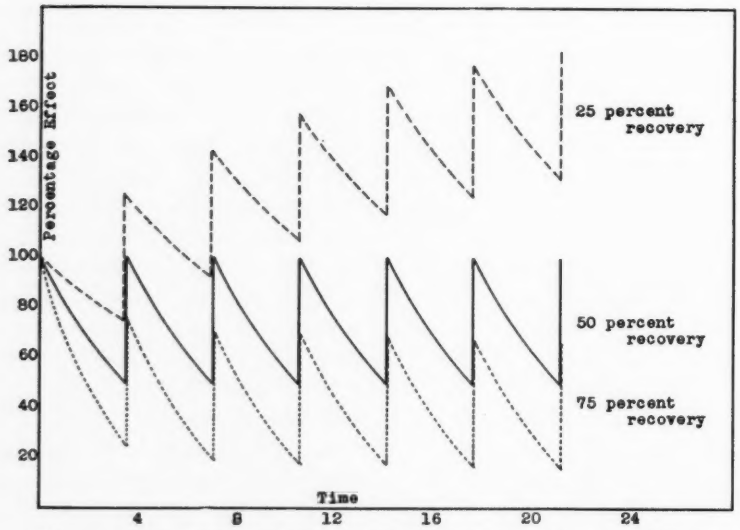

Fig. 6. Curves illustrating how the irradiation effect would be maintained for two responses when one recovers faster and the other slower than a third maintained at saturation.

human tissues in order that the factor may be properly considered and used advantageously in clinical radiotherapy.

SUMMARY

1. Since a certain response to x-rays in

2. In Arbacia, recovery was found to begin immediately after irradiation and proceed at a fixed rate. Further, the recovery process was found to be in progress even during exposure.

3. In Cumingia, recovery did not occur,

thus presenting a relationship, so far as the two organisms are concerned, of differential recovery.

4. Experiments were performed to determine the influence of differential recovery when the time-factor in irradiation is varied. It was found that differential irradiation effects can be controlled to some extent by properly adjusting the duration of exposure.

5. It was pointed out that the possibility of obtaining more favorable results in clinical radiotherapy by using the saturation method of exposure depends upon the relative rates of recovery of the normal and tumor tissues rather than the "getting-in" of more radiation.

Acknowledgments.—The writers wish to express their indebtedness to Dr. G. Failla for having suggested the concept of differential recovery and for helpful suggestions during the course of the work.

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AMERICAN PIONEERS IN RADIUM THERAPY

By BENJAMIN G. P. SHAFIROFF, M.D., BROOKLYN, NEW YORK

A TRIBUTE should be paid to a group of American physicians and surgeons who have laid the foundation of a new type of therapy in medicine. These men, working independently and without the aid of organized support, established the therapeutic value of radium in the treatment of cancer and of various benign dermatologic and surgical conditions.

Radium was discovered by Mme. Curie at the end of the nineteenth century. In 1901, Henri Becquerel inadvertently acquired a chest burn due to the storage of some pure radium in his waistcoat pocket. Radium therapy had its inception from this famous "Becquerel burn." Shortly afterward Pierre Curie applied a small amount of radium to his forearm to note how it affected human tissues. Slowly the potentialities of this powerful "chemical" agent became manifest as the radiated area passed through the stages of swelling and erythema to ulceration and finally to healing. The French physicians readily recognized the possibilities of radium therapy and soon several reports were published about its remarkable activity. The first scientific announcement to the world was made by Chéron in 1909 at the Académie de Médecin.

As the news of this substance spread throughout the scientific world, American physicians abroad returned home with stories of miraculous cures and the marvelous powers of this mysterious agent—radium. Impressed by the reports of their European colleagues, several American physicians bought small amounts of radium. Robert Abbe (New York), Francis H. Williams (Boston), William H. Morton (New York), and Howard A. Kelly were the first of such early purchasers. It was Dr. Howard A. Kelly who, by virtue of his scientific studies, his published works, and his zealous defense against all ignorant op-

ponents of radium, led to the establishment of a new department in medical therapeusis —that of radium therapy. He justly deserves the title of "Father of Radium Therapy" in America.

The beginning of the twentieth century was the ideal time for presentation of radium to the medical world. The diagnosis of cancer was established; its anatomic and microscopic basis was recognized. In spite of the numerous radical operations for malignant conditions, recurrences were frequent. Surgeons were quick to recognize that radium would fill a need—it would act in cases in which the scalpel and the human eye could not.

The remarkable early reports by Kelly, Abbe, and Morton stimulated their American colleagues to investigate the virtues of this new agent. It was presented at a time when Europe was engaged in a world conflict—foreign physicians could not give to it as great consideration as they normally would have done; nevertheless, we must not forget the works of Chéron, Louis Wickham, Regaud, Doderlein, Soddy, and Rutherford. The work of American surgeons who took up the burden of investigation of this problem is noteworthy and their results form a monument of American ability and endeavor.

The readers of this historical sketch will be interested in the report of cases treated as early as 1905, the manner of treatment, and the care with which investigators studied the progress of their cases. The following is culled from Dr. Morton's private notebook.

"Miss L. V., age 22, May 17, 1905 About one year previous to this date, patient noticed a swelling about the size of a walnut in the region of the upper third of the humerus. In six months the growth gradually increased to the size of a lemon. Accidentally striking her arm against a hard object, a fracture occurred at the site of tumor. Patient went to a hospital where part of growth was removed and pronounced cancer. A large tumor recurred at the site of incision. Pathologic examination at the Post-graduate Hospital, New York, was sarcoma. The patient had emaciated rapidly, had lost her appetite, presented extreme cachexia, and her skin was of a yellowish and sallow hue. No hope whatever was entertained of saving her life but as a last resort amputation of the arm at the shoulder was proposed. This was rejected both by the mother and patient. I possessed a glass tube of radium chloride containing 100 milligrams of an estimated activity of 20,000. I inserted the radium within the tumor and placed the patient in the Post-graduate Hospital. The tube remained continuously within the wound for about six weeks. Within five weeks the patient had gained seven pounds and was able to dispense with the splint which she had worn constantly with heavy bandages. At the end of three months the wound, after discharging less and less freely, was nearly healed. Attendant points of interest are the utter hopelessness of relief by other measures. This was evident in the x-ray of the humerus before treatment, showing the radium embedded in the tumor and a recent x-ray showing the healed humerus."

Dr. Morton reported this case nine years after the radium treatment. Incidentally, he was one of the first to implant radium within a tumor. This method of interstitial radium therapy is now a much used process in cancer surgery.

As is true with every new medical discovery, radium appeared in the beginning to be of value in almost every clinico-pathologic condition. W. H. Cameron (Pittsburgh) reported on the value of radium in alveolar pyorrhea. Frank E. Simpson (Chicago) addressed the Dermatology Section of the American Medical Association in 1913 on the startling results obtained by the use of radium in the treatment of angioma, lupus, psoriasis and keloid. Dr. Frederick Proescher published scientific reports on the intravenous injections of radium salts and the relief this medication gave in rheuma-

tism, gout, arthritis deformans, and hypertension. "Radium in Internal Medicine, Its Physiological and Pharmacological Effects" was investigated by L. G. Rowntree and W. A. Baetjer, and their report published.[1] Dr. Francis H. Williams and Dr. S. W. Ellsworth published an excellent article on "The Treatment of Superficial Newgrowths by Pure Radium Bromide" in the journal "Radium."

It is interesting to note that Dr. Abbe, an extraordinary and skillful surgeon, a pioneer in many of the developments of modern surgery, should also have become the earliest and greatest exponent of surgery's antithesis —curietherapy. Dr. Abbe, early in 1905, obtained a small amount of radium from Mme. Curie, which he carefully, though hesitatingly, used in many conditions. His observations and deductions as to the value of radium show high scientific ability. The following are his notes on one of the first cases treated in America:

"In December, 1905, I was confronted by a case of extreme anemia from fibroid menorrhagia in which it seemed unwise to operate. The patient, a physician's wife, was 44 years old. Under ether I curetted and introduced a glass tube containing 50 milligrams of pure radium bromide for ten minutes. She progressively improved, menstruated normally, and recovered her health. In one year the tumor was perceptibly smaller. During the following year, I applied radium again on one occasion for forty-five minutes and on another for ten minutes, thus feeling my way along carefully to ascertain the safe and efficient dosage. The patient has remained in perfect health ten years. It will surprise only those who have not witnessed this energetic action of radium to know that so small a tube of this powerful agent can exert a restraining alternative force."

With his total of 100 milligrams of radium, Dr. Abbe diversified its applications to all fields of surgery. He invented many ingenious devices for the application of radium to various organs of the body. He was among the first to distinguish between the therapeutic effects of beta and gamma rays. As the surgeon to the Babies' Hospital he successfully treated numerous angiomas, lymphangiomas, and pigmented nevi. Dr. Abbe, the kindly Professor of Surgery at the New York Post-graduate Hospital, was a keen judge, always ready to recognize the new and apply it. The kindliness of this man toward his fellow-workers is shown by the following note:

"I was impressed by the large proportion of this noble body of workers (roentgenologists) who had suffered from all degrees of roentgen injuries, from simple hyperkeratoses to amputation of one or more fingers of one hand or both. One physician, illustrating a type of severe injury of the hands of one of the pioneers and foremost authorities in roentgen work, came to me two years since with both hands covered with patches of thick epithelioma and crusted skin, cracked and sore, compelling him to use gloves and cerates for even decent comfort. During several years he had forestalled the dangerous second stage by having surgeons excise and skin graft several parts. At last he was disheartened and refused to suffer longer the pain of these treatments, the worst of which he thought was carbon-dioxide freezing. I loaned him one specimen of radium to use, indicating the number of minutes for each twenty or thirty areas. The result was better than by any surgical method he knew."

Dr. Abbe died of a persistent anemia, possibly the result of long-continued handling of radium. He was kept alive for several years by transfusions every three weeks, during which time he bore his suffering with the greatest cheerfulness and would discuss optimistically and interestedly the details of his case.

The activities of Howard A. Kelly in the field of radium therapeutics were many. He not only was the greatest exponent of the

[1]Jour. Am. Med Assn., 1913, LXI, 16.

use of radium for uterine pathologic conditions, but found many other uses for radium in the treatment of malignancy of the mediastinum, in Hodgkin's disease, and leukemia. He was the great defender of radium. He negotiated with the Government for the American production of radium. He stimulated Dr. Parsons and the Bureau of Mines engineers to develop an American method to isolate radium. He invested thousands of dollars of his own to found a hospital and radium institute for the treatment of those who were afflicted with all types of malignant diseases. He vigorously defended radium against the arguments of those opposed to its use, especially Dr. John Deaver. Together with Curtis F. Burnam he published concise, scientifically detailed observations on radium in the treatment of gynecologic malignancy. His papers are among the classics in medicine. His varied activities as pioneer, experimenter, and advocate of radium will cause him to be remembered not only as a great surgeon but also, as has already been said, as the "Father of Radium Therapy" in America.

Many of the specialists have recognized the possibilities of radium in specific lesions in various parts of the body. Guttman early recommended the use of radium in nasal and laryngeal malignancy. Edmund W. Clap gave an interesting summary of "Progress in Ophthalmology with Radium" in 1915. In the treatment of genito-urinary diseases Winfield Ayres, of New York, was the first American physician to implant radium through a cystoscope. Closely following his work was that of Hugh Young, of Baltimore, who invented many ingenious radium applicators in the treatment of bladder and prostatic malignancies. Barringer, inspired by the classic work of Pasteau and Degrais, published excellent papers on the value of radiation in prostatic malignancy. Dr. J. Bentley Squier early recognized the value of radium in genito-urinary malignancy: his consideration of the value of suprapubic incision and implantation of radium through such a wound showed his clinical foresight.

The development of radium therapy is closely interwoven with the progress of gynecology during the last decade. Kelly, Burnam, Janeway, C. Jeff Miller, and Schmitz were the earlier contributors on this subject.

The recognition of the different therapeutic effects associated with beta and gamma radiation made its employment of value in dermatology. The studies of Simpson, Fox, Pusey and others have established the indications and contra-indications for its use in this work.

On October 26, 1916, at the Rittenhouse Hotel, in Philadelphia, a group of about twenty-two men organized themselves as the American Radium Society, in order to promote the scientific study of radium therapeutics and to seek to maintain a high ethical standard among those using it. The first president of this Society was W. H. B. Aikens, M.B., of Toronto, the vice-president Russel H. Boggs, M.D., of Pittsburgh. Some of the more prominent active members were J. B. Bissell, of New York, nationally known surgeon and radium specialist, and destined later to become president of the Radium Society. Russel H. Boggs had the largest radium practice in western Pennsylvania and was famous for his excellent articles on radium therapy while serving in the capacity of Professor of Radiology at Western Pennsylvania Medical College. W. H. Cameron, an early pioneer in radium, is now associated in a consulting capacity with the Radium Corporation in New York. Howard Fox, Professor of Dermatology, was interested in radium as it concerned diseases of the skin. I. Levin, M.D., was prominent for his experimental studies on the action of radium. C. Jeff Miller, M.D., of New Orleans, later to become president of the American College of Surgeons, was a zealous advocate for the use of radium in

uterine pathology. Frank E. Simpson, who founded the Simpson Radium Institute in Chicago, was a leader in the use of radium in dermatologic practice. Henry Schmitz, M.D., to become the third president of the Society, was among the first members, as well as H. K. Pancoast, M.D., Professor of Radiology at the University of Pennsylvania. These are a few of the famous names.

At this point tribute should be paid to W. H. B. Aikens, M.B.(Tor.), the first president of the Society. A graduate of the University of Toronto, he was the leading radium and cancer expert in Canada. His studies on the use of radium were manifold; his observations were always sound. To him and his sincere efforts, I believe the American Radium Society owes its success, and the fact that it has now grown to be one of the finest specialized medical groups in the country.

Closely associated with the growth of radium therapy was the growth of cancer hospitals, great radium centers where all specialized treatments could be given. These institutions were established in several parts of the country, among the earliest being the Memorial Hospital, of New York, where a scientific group for the study of radium therapeutics was developed under the able leadership of Dr. Janeway, Dr. Ewing, and Dr. Barringer. The accurate clinical observations by Dr. Janeway, his development of interstitial radiation by needling, and the substitution of radium emanation for radium were some of the crowning achievements in his career. The institution and the men he taught constitute a memorial to the ability of Dr. Janeway, while his book on "Radium Therapy at the Memorial Hospital" was widely translated and forms a part of the scientific literature of the world.

Philadelphia, always the center of advanced medicine, had its cancer hospital associated with the University of Pennsylvania. Here the early workers were Dr. Pancoast, Dr. Clark, Dr. Norris, Dr. Frazier, and Dr. Pfahler. Dr. Clark and Dr. Norris were noted for their classical work on "Radium in Gynecology"; Pfahler has become famous for his treatment of malignancies of the mouth. At Jefferson Medical College there was Dr. Newcomet, author of the first American book on "Radium Therapy," always a sincere worker and a prolific writer.

In Boston there is the Collis P. Huntington Memorial Hospital, founded by the efforts of Harvard's great surgical master, Dr. Warren. There Dr. William Duane, formerly of the Curie laboratory, discovered the method of collecting radium emanation now universally used. Other famous names connected with that institution were Dr. Robert Greenough, Dr. Ordway, and Dr. Bovie.

Among other early institutions were the University of Cincinnati, where the Ransohoffs did pioneer work in radiation of the breast, uterus, and thyroid. The New York State Institute for the Study of Malignant Disease developed through the tireless efforts of Dr. Gaylord. The cancer division of the City of New York was created by Dr. Bissell, who brought back the technic for implanting radium needles in cancerous growths, a method which he acquired at the Radium Institute in London. The work of Bissell was carried on by Isaac Levin, M.D., and, later, by the present chief, Ira I. Kaplan, M.D.

Radium therapy has not always had the universal approval it now enjoys. The criticisms of Dr. Deaver at the time of his presidency of the American Surgical Association to the effect that radium was of little use, met with world-wide circulation. The denial of this statement from those in surgery who had experience with this method, was equally emphatic. The experience of Dr. Kelly as a leader in surgery and radium therapy was the best rebuttal. In spite of

these criticisms, radium has retained its place in medicine and surgery, its limitations and indications have been evaluated, and it is now a recognized part of the armamentarium of the cancer surgeon.

This, in brief, is the story of the contributions by American physicians on the uses of radium. As is unavoidable in so short a summary, many of these great names do not receive their due credit, many names are omitted, and many interesting subjects are not presented.

THE SCIENTIFIC CONTROL OF RADIOGRAPHIC RESULTS[1]

By CHARLES WEYL, S. REID WARREN, JR., and DALLETT B. O'NEILL,
PHILADELPHIA

INTRODUCTION

THE progress of the radiologist in his attempts to follow the course of disease by means of radiographic diagnosis is often impeded because radiographs taken at different times in his own laboratory are not comparable. The lack of comparability between films submitted by his patient from other laboratories than his own and those which he may take under his own direction is even more striking.

There are many variables in radiographic processes which contribute to these vexing differences. These causes might be grouped generally:

1. Personal opinions concerning the type of radiograph which is diagnostically most effective.
2. Types of x-ray machines.
3. Size and position of patient.
4. Types of x-ray tubes.
5. Intensifying screens.
6. X-ray films.
7. Cassettes.
8. Dark room technics.
9. Variations of power supplies to x-ray machines.
10. Changes in output of x-ray tube due to overloading.

For each of these general causes there might be listed several contributing factors which cause variation in radiographic density and radiographic contrast. For example, there might be listed under

6. X-ray films:
   - *(a)* Variations at any one time between the films of various manufacturers.
   - *(b)* Variations with time of the film of one manufacturer.
   - *(c)* Variation of film characteristics over the area of a film.

Some of these variables are relatively unimportant. For example, most x-ray films manufactured to-day are found to have characteristics sufficiently uniform over the area of one film so that no difference is observable. Nevertheless, the entire problem is extraordinarily complex and may be attacked only by careful analysis of the relative importance of each contributing cause for variation and by a standardization of procedure which will make possible the control of these variations.

It is the purpose of this paper to submit to the radiologist some of the tests which he might make in his laboratory to aid him in his present problems and to suggest that the co-operative collection of data from such

[1]A summary of a part of the work conducted at the Moore School of Electrical Engineering and the Henry Phipps Institute, University of Pennsylvania, under a research grant by the National Tuberculosis Association.

tests might provide for a general standardization of radiographic technic.

TEST APPARATUS

The complete electrical testing of machines should rightly be accomplished in the well-equipped electrical engineering laboratory. Such tests have been made and the methods have been described in a paper published some time ago.[2]

The tests to be described are based entirely upon the assumption that the radiologist is interested chiefly in the radiographic results. Therefore, radiographic density and radiographic contrast are accepted as the fundamentals from which variations in results are interpreted.

The photometric density *(D)* of an area of any exposed and processed x-ray film is defined as the logarithm to the base ten of the ratio of the light intensity incident to the area, to the light intensity transmitted through the area. The contrast between two differently exposed areas of the processed x-ray film is equal to the difference in densities of the two areas. From these definitions it is clear that the values of density and contrast are pure numbers. Since the incident light has greater intensity than the transmitted light the number representing density is always positive. If a film transmits 1/10 of the incident light, then the density is equal to one.

Densities of areas of radiographs of parts of the human body may vary between the limits $D = 0.05$ to $D = 2.5$. However, the range of densities of greatest interest to the radiologist is from $D = 0.15$ to $D = 1.5$. The tests which are to be described provide results within this latter range; therefore, the methods provided for producing x-ray densities and for measuring them will be confined to this region.

The first piece of equipment necessary is a test object which may be radiographed conveniently and which will have always the same x-ray absorption characteristics. Many workers in the past have found that an aluminum ladder satisfies this requirement and it is, furthermore, a simple apparatus to construct. Since sheet aluminum may be purchased cheaply in ⅛-inch plates it is suggested that a ladder consisting of eight steps from ⅛ inch to 1 inch thickness be built out of such plates. It is convenient to make each step about ½ inch wide and the ladder 2 inches wide. Such a ladder provides a means of obtaining, under conditions of normal radiographic technic, the full range of densities discussed above.

Radiographs of the aluminum ladder, after processing, provide eight film areas of different densities which may be correlated with the conditions set up for taking the radiograph. It is important to measure the densities to an accuracy of about 1 per cent: it is not sufficient to compare films by eye with the aid of a viewing box. The density measurement may be most effectively accomplished by means of a photo-electric densitometer. This instrument consists of the source of light, lenses for collimating the beam in a direction perpendicular to the film, an aperture through which a part of the light travels after passing through the film, a photo-electric cell mounted directly below the aperture, and some kind of electric indicating device indirectly to measure the light which falls on the photo-electric cell. Such a densitometer may make use of a vacuum tube amplifier[3] or a photo-electric cell which may be connected directly to a microammeter. Since it is exceedingly expensive to construct a densitometer which will measure the absolute value of density, it is more economical, therefore, to construct a comparative densitometer and to employ a calibrated density tablet as a standard.

[2]Charles Weyl, S. Reid Warren, Jr., and F. Maurice McPhedran: Methods of Measuring and Recording Roentgen-ray Tube Currents and Voltages. Am. Jour. Roentgenol. and Rad. Ther., December, 1931, XXVI, 871-877.

[3]Charles Weyl and S. Reid Warren, Jr.: A Comparative Photometric Densitometer for the Measurement of X-ray Film Densities. RADIOLOGY, November, 1931, XVII, 946.

Such density tablets may be purchased from any film manufacturer. It is advisable to have one constructed with 15 steps, each about one inch square, with densities varying linearly from 0.05 to 1.50. The manufacturer in setting out to make such a tablet can accomplish his work much more quickly if the absolute value of the density of each step is not exactly specified. He can make easily a 15-step tablet for which the difference in density between any two successive steps is approximately 0.10 and then calibrate the tablet with extreme accuracy. It is quite satisfactory to allow the manufacturer to take this more simple course, since, so long as the density of each step is known accurately, it is not necessary for the purposes at hand that the density differences between successive steps be exactly the same.

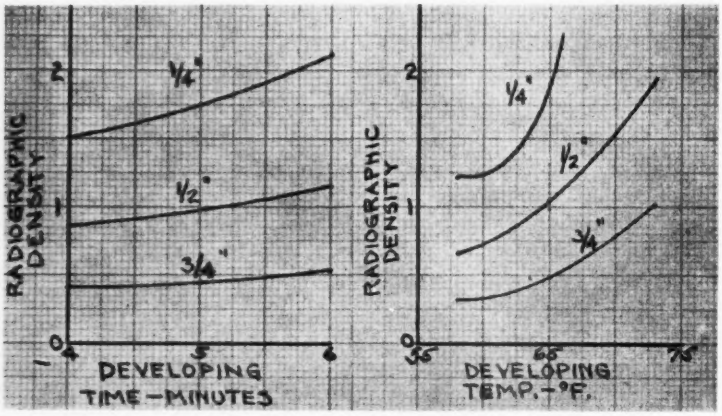


Fig. 1. Curves showing radiographic density variations, with developing time and with developing temperature, for ¼, ½, ¾ inch steps of an aluminum ladder. Radiographs were made with intensifying screens.

Some means should be provided for making routine tests concerning the sizes of the focal spots of the various x-ray tubes used in the laboratory: it is also important to know whether or not the x-rays emanate uniformly from the area of the focal spot. A partial evaluation of these factors may be accomplished by means of a pinhole camera. Such a camera may be constructed by making a rectangular framework of angle brass $5 \times 5 \times 12\frac{1}{2}$ inches. Sheet lead of thickness 1/16 inch is mounted on this framework on all six sides and carefully soldered, so that the box is x-ray-proof. At the center of one of the smaller ends a hole 1 inch in diameter is cut and a brass ring soldered in place. The hole in the center of the brass ring is ¾ inch in diameter. Lead plugs of diameter ¾ inch, with a ¼ inch shoulder at the outside, are then constructed with pinholes of various size, from 1/32 to 1/16 inch in diameter, in the center. These plugs may be fitted into the brass ring. At the small end of the box opposite the pinhole, arrangements are made for mounting a piece of x-ray film within an envelope of black paper, fixing the envelope between two thin pieces of bakelite and slipping the assembled "cassette" into the box. The distance between the pinhole and the plane of the film is carefully measured. The use of a pinhole film distance of 12 inches provides that small errors in the measurement of the distance from focal spot to pinhole, which is always difficult, will not cause appreciable

error in the calculation of focal spot size from the pinhole radiograph. By making the focal spot pinhole distance 6 inches a 2-to-1 enlargement of the focal spot may be obtained. Enlargements of greater order, since over-exposure or under-exposure may give a false idea of the actual size of the focal spot. It is not advisable to rely entirely upon the results of pinhole radiographs since a great number of errors may

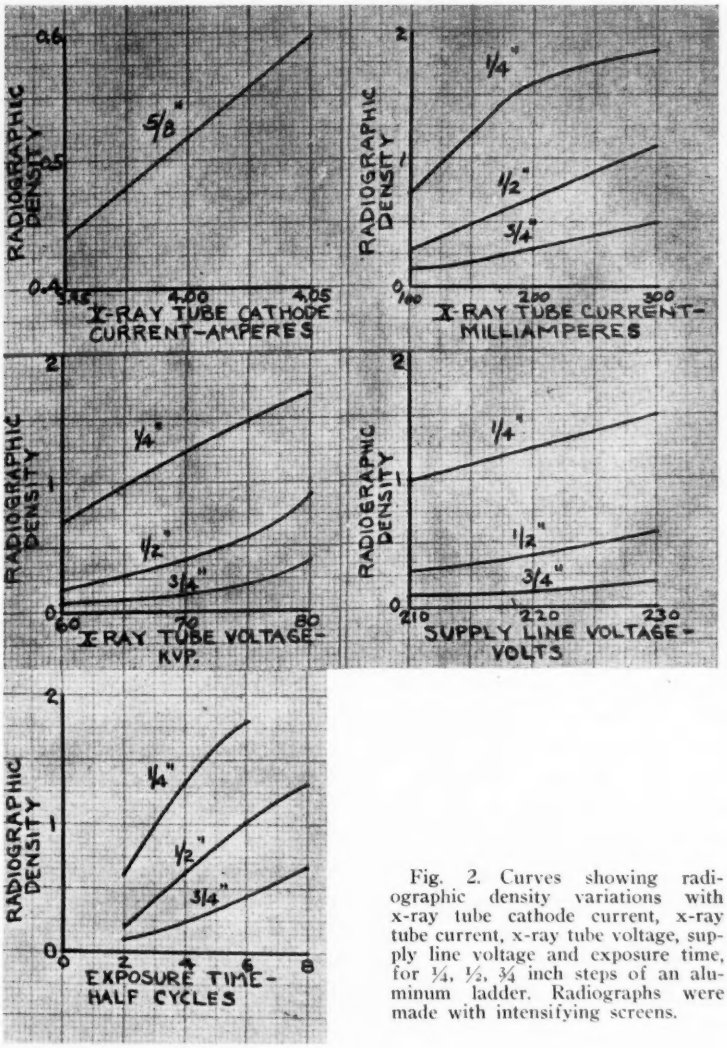


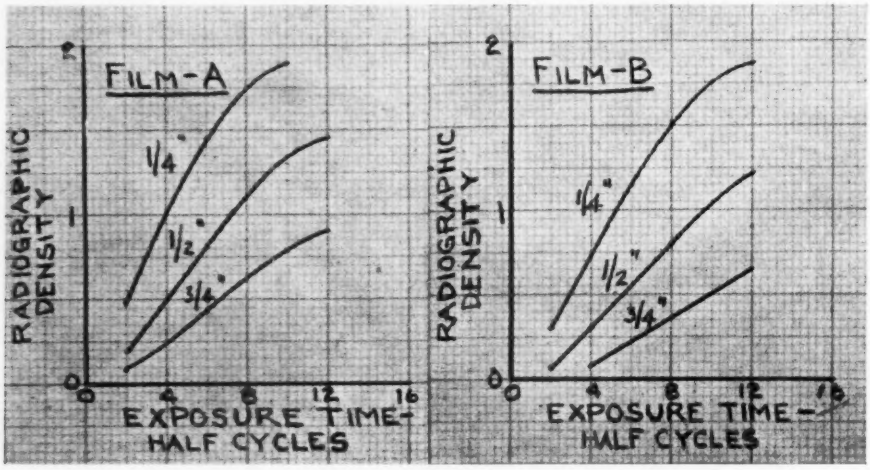
Fig. 2. Curves showing radiographic density variations with x-ray tube cathode current, x-ray tube current, x-ray tube voltage, supply line voltage and exposure time, for ¼, ½, ¾ inch steps of an aluminum ladder. Radiographs were made with intensifying screens.

valuable for determining the energy distribution of the x-ray source, may be made by further reduction of the focal spot-pinhole distance. It is to be emphasized that pinhole radiographs must be made with care contribute to the false interpretation of results.

A second method of investigating the distorting effect of the finite size of the focal spot consists in radiographing a wire mesh

which is fixed at an angle with an x-ray film. Further discussion of tests concerned with the distorting effect of the focal spot will be reserved for a later paper.[4]

It is interesting to note that the perception of density differences is affected by a number of psychological and physiological phenomena. Without considering the details, it is sufficient to note that the average person with keen vision can perceive a density difference of about 5 per cent if the areas of different density are contiguous and if the borderline is sharp. If there is a gradual change of density, if, in other words, the border between the two areas is wide, then a greater density difference is necessary for perception by the average person. The values of these perceivable differences may be influenced by so many factors concerned with size, shape, and position of the two areas, the color and intensity of light in which the areas are viewed, and the personal characteristics of the individual who observes that it seems sufficient for the moment to choose a density difference of 10 per cent at a density of 0.5 as a standard maximum variation to be allowed in practice. Some of the data given below are based on the assumption of this maximum allowable variation.



Figs. 3-*A* and 3-*B*. Film comparison tests. Variation of radiographic density with exposure time for two film samples, A and B. X-ray tube current 200 ma., voltage 80 K.V.P., focal spot-film distance 70 inches. Intensifying screens were used.

To summarize, then, the instruments required for the experiments to be described are an aluminum ladder, a photo-electric densitometer with a standard density tablet, and a pinhole camera for radiography of focal spot images. It should be emphasized that if the tests are to be continued over a considerable length of time and if it is desired that the results be comparable over the whole period, then a cassette and an associated pair of intensifying screens should be used for this purpose only, as standards. Perhaps it is worth while to note that high quality screens, not of the highest speed available, are most likely to maintain constant intensification over long periods. If it is possible, one x-ray tube should be reserved for the tests and used for nothing else. If these precautions are taken, then, if there is change in radiographic result which appears to be caused by changes in screen output or in tube output, the use of the standard screens and the standard tube

[4]Dr. Willem Bronkhorst has investigated many radiographic problems concerned with radiographic density, contrast, and distortion in his book entitled, "Contrast and Sharpness in Radiographs." An English translation of this book is in process of preparation.

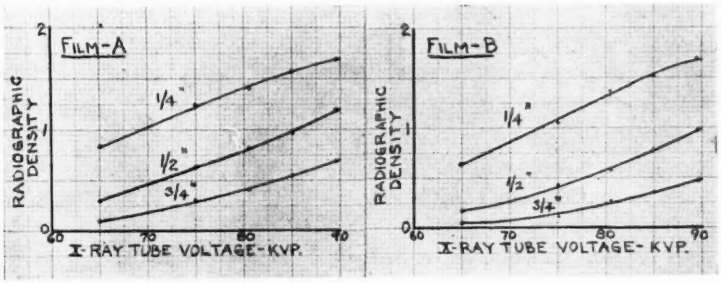
will make possible the identification of the cause of such changes.

THE CONTROL OF DARK ROOM TECHNIC

It is absolutely necessary carefully to control all steps in the processing of x-ray film if radiographic tests are to be used as standards. Accurate control of the time and of the temperature of development is extremely important. Experiments have been performed to determine how much variation of these two factors is allowable, assuming the maximum density variation of 10 per cent. Ten radiographs of an aluminum ladder were made on one film, the radiographic technic being the same for all radiographs:

X-ray tube voltage—80 K.V.P.
X-ray tube current—200 ma.
Exposure time—6 half cycles (1/20 second)
Focal spot-film distance—70 inches.

Of these ten undeveloped radiographs, five were separated and processed individually with different developing times from 4 to 6 minutes at 65° Fahrenheit. The remaining five were also processed separately, while the time of development was maintained constant at 5.5 minutes and the temperature of the developer was varied from 59° to 73° Fahrenheit. The data are given in curve form in Figure 1. These data, and all those given in the following pages, were obtained as the results of single tests, with a particular type of film and screen. The results, therefore, are not to be interpreted as general, but simply as specimens representing the test methods described.



Figs. 4-*A* and 4-*B*. Film comparison tests. Variation of radiographic density with x-ray tube voltage for two film samples, A and B. X-ray tube current 200 ma., exposure time 6 half cycles (1/20 second), focal spot-film distance 70 inches. Intensifying screens were used.

It may be inferred from these data that it is advisable to maintain the temperature of the x-ray film developer constant to ± 0.4° F. and that the time of development should remain constant to ± 25 seconds if it is desired that these two factors produce no observable density difference.

It is practically impossible to maintain constant output in the dark room simply by changing the time of development in proportion to the number of films previously developed. It is imperative to provide a closer control over this part of the general processing. Dr. Chamberlain and Dr. Newell[5] have described a method of making radiographs of an aluminum ladder, of cutting strips from the undeveloped film and developing them successively at various times throughout the life of the developer, to determine the changes in density caused by developer fatigue. By combining this method with the use of a densitometer for the accurate measurement of density it is possible to maintain the output within satisfac-

[5]W. E. Chamberlain and R. R. Newell: Development of Roentgen Films: A Method of Determining the Potency of the Developer. Am. Jour. Roentgenol. and Rad. Ther., May, 1930, XXIII, 549-552.

tory limits. If the dark room is particularly busy, it is suggested that such tests may be made about twice a day; otherwise, they may be made once a day or three times a week as experience will teach is necessary.

After the film is developed it is removed from the solution and rinsed. Since each film carries along a certain amount of the developing solution which is washed away by the rinse water, it is important that the developing solution so lost be replaced by fresh developer. However, it is equally important not to add large quantities of fresh developer since there might result a sudden change in density and contrast qualities of the films being processed at the time of this addition. It is suggested, therefore, that fresh developer be added routinely about once every hour and carefully stirred to assure complete mixture of the fresh with the old solution.

THE EVALUATION OF VARIATIONS IN THE ELECTRIC CIRCUIT IN TERMS OF RADIOGRAPHIC DENSITY

It is well known that changes in x-ray tube voltage, x-ray tube current, and time of exposure will produce variations in the radiographic result. A change in x-ray tube voltage is generally caused by a change in line voltage. A change in x-ray tube current may be caused by variations in the cathode current which, in turn, is a result of change of line voltage or by instability of the x-ray tube. Small variations in the time of exposure may generally be charged to mechanical or electrical deficiencies of the timer. It is inconvenient at present to arrange for the accurate measurement of all of these electrical quantities for each exposure. However, experiments have been performed to determine what changes in these quantities will cause perceptible changes in radiographic density, and the results are given graphically in Figure 2. The data indicate that the several factors must vary within the limits shown in Table I, if the variation of a single factor is to cause no perceptible radiographic difference.

Once more it is emphasized that these results describe one particular set of experimental conditions. It would be of great value to obtain such data from many laboratories for complete analysis.

By watching carefully the prereading voltmeter of the x-ray machine, the readings of a ballistic milliammeter connected in series with the x-ray tube anode, and the readings of the cathode ammeter, it is possible to correlate density variations with changes in values of these electric quantities.

It is particularly interesting to make twenty or thirty radiographs of the aluminum ladder under supposedly identical conditions, to process the films at the same time, and to measure the densities of all steps of all the films. The results of such tests may be plotted for each step of the aluminum ladder to show the variation which might be expected under normal conditions. Such results will aid considerably in the evaluation of subsequent tests. The range of densities obtained for any particular ladder step represents a sort of "figure of merit" for the complete radiographic installation with a particular x-ray tube, film, and intensifying screens.

EFFECT OF THE VARIATION OF FOCAL SPOT-FILM DISTANCES

It has been clearly demonstrated that over a range of densities from 0.15 to 1.5 the radiographic density obtained varies inversely as the square of the distance from the focal spot to the film if all other technical factors are kept constant. Outside of these limits other factors become important. At densities greater than 1.5 many x-ray films saturate so that the density variation does not follow the inverse square law. Below a density of 0.15 the processing fog may invalidate this law.

TABLE I

Varying Factor	Allowable Variation for 10 per cent Change in Radiographic Density	Desired Value of Varying Factor
X-ray tube cathode current	± 0.015 ampere	4.00 amperes
X-ray tube current	± 12.5 milliamperes	200 milliamperes
X-ray tube voltage	± 1 K.V.	80 K.V.P.
Supply line voltage	± 2.25 volts	220 volts
Exposure time	± 0.0025 second	0.05 second
	± 0.3 half cycle	6 half cycles

THE COMPARATIVE TESTS OF X-RAY FILMS AND OF INTENSIFYING SCREENS

The experiments described below are easy to perform and provide a general though not a complete comparison of films and screens. For the experiments one set of x-ray intensifying screens should be used for the comparison of various x-ray films: similarly, for the comparison of various intensifying screens, one type of film should be used throughout the experiments. Otherwise the tests are similar and it is necessary only to describe the film tests to make clear the entire process.

For each sample of x-ray film to be tested, it is advisable to make a series of two experiments. For the first set the controlled variable factor is the time of exposure. A technic is chosen to provide a density of about 1.00 for the half-inch step of aluminum. To illustrate by an example, results are reproduced in Figure 3 of a test wherein this technic was 80 K.V.P., 200 ma., 6 half cycles, 70 inches. With the machine fixed at the setting for 80 K.V., 200 ma., radiographs were taken successively for exposure times of 2 half cycles, 4, 6, 8 and 12 half cycles. A ballistic milliammeter was read for each exposure and the radiographs were made on one piece of film. The same test was made on a piece of film of another type, the two test films being processed at the same time, the densities for each step for each radiograph being carefully read by means of a photo-electric densitometer. For each step a curve was made by plotting as abscissas the exposure time in half cycles and as ordinates the densities.

A second test is made by using the x-ray tube voltage instead of the exposure time as the variable factor. This test is more difficult to control accurately and therefore the curves which are drawn represent less accurately the true conditions. The results of the voltage tests are shown in Figure 4. The actual points representing each curve in both sets of diagrams are clearly marked to show this variation. The general conclusions to be derived from these tests are:

1. Film A gives greater density by about 25 per cent for most technics within the limits of the data.
2. Film B offers considerably more contrast (of the order of 20 per cent) in the radiography of thin parts.

The complete detailed analysis of such data is complicated. Much further work will be undertaken in order to clarify this important subject.

The uses of these simple tests are many. It is possible to evaluate the variation in the manufacturers' output from month to month by making these tests regularly. Figure 5 shows the results of such a test over a period of three months.

Perhaps it is much more important to employ these tests to compare the sample films presented by salesmen in their efforts to obtain new business. The radiologist should certainly be the judge in the question of what x-ray film he uses, and it is of con-

siderable value to provide for him a simple method of determining scientifically which film is best adapted for his purpose. If he can find time to perform such experiments, he will no longer be at the mercy of salesmen who show him test films taken under conditions of which he has no knowledge.

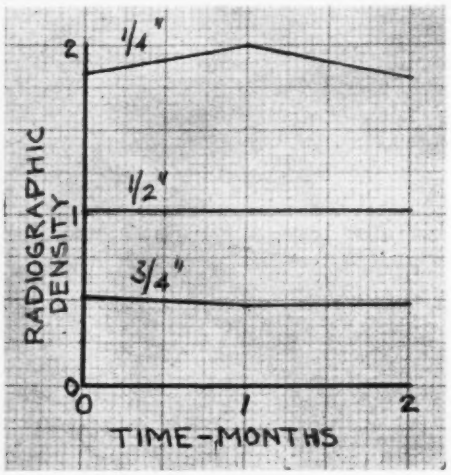


Fig. 5. Test of variation of manufacturer's film output. X-ray tube voltage 80 K.V.P., current 200 ma., time of exposure 6 half cycles (1/20 second), focal spot-film distance 70 inches. Intensifying screens were used.

No considerable amount of work has been done to show how tests of this nature may be interpreted in terms of diagnostic value of radiographs of parts of the human body. There is a considerable field for research which must be covered thoroughly before this problem can be completely solved. However, it is believed that if a number of radiologists make tests of this type and if they collaborate by carefully collecting and analyzing their results, a helpful standardization may be accomplished.

Comparative tests of intensifying screens may be carried out in exactly the same manner. The general roentgenologist often decides to use one type of intensifying screen and one type of film for all of his radiographic work. It seems quite likely, however, that by careful analysis of experimental data he might find that the use of two or three types of film and two or three types of intensifying screens would make possible the segregation of certain types of radiography in such a way that better results might be obtained.

X-RAY TUBES

It has been suggested that the combined use of a pinhole camera and a wire mesh might provide full information concerning the distorting factors of x-ray tube focal spots. The details of such investigations will be left for future consideration. Nevertheless, it is important to note at this point the advisability of making routine pinhole radiographs of all of the tubes generally used for clinical work. If these radiographs are made once every month, it is possible to discover changes in the size and shape of the focal spot and changes in its output due to overloading. In order to obtain the least possible radiographic distortion it is best to employ the x-ray tube at its maximum capacity. Therefore, it is quite probable that overloading may occur occasionally. Under these conditions it is particularly important to examine the focal spot routinely.

MACHINES

When the radiologist desires to purchase an x-ray machine he is concerned with the problem of discovering what he may buy with the money available which will be most satisfactory for his particular purpose. The data generally provided to him consist of catalogue sheets describing the apparatus and containing photographic reproductions of parts of the equipment. Very often he is given a demonstration at the salesroom of a particular manufacturer. If the demonstration gives films of a type with which he is not familiar, he is in no position to pass judgment. The tests which have been described above provide that he may take

with him to any demonstration his own cassette and intensifying screens, his own film, and his own aluminum ladder. He may then watch carefully while radiographs of this ladder are made under his direction and he may take the films back to his own dark room for processing. A series of such tests made with various machines in which he is interested would provide him with concrete facts to aid him in making a choice. If the machines are constructed with entirely dissimilar circuits, then comparison may no longer be made between the test films. This important matter will be discussed below.

VARIOUS TYPES OF RADIOGRAPHIC MACHINES AND THE PERSONAL FACTOR IN THE DETERMINATION OF RADIOGRAPHIC TECHNIC

All of the large radiographic machines now available fall into three electrical classes: (1) Single-phase, 4-valve equipment; (2) three-phase, 6-valve equipment; (3) condenser discharge equipment. The wave forms of the x-ray tube voltage and x-ray tube current differ for each of the three types. Since the quality of the x-ray output is a function of these wave forms, the radiographic density and contrast obtained with the three systems differ considerably—differences which are so great that there is no possible accurate correlation of data upon which a fair comparison can be made. There are three different types of radiograph which may be obtained. Since x-ray machines are quite expensive, it is difficult to discover which type of machine may be most satisfactory for all kinds of work and for all roentgenologists. In fact, it is quite likely that no such choice can be made.

Each radiologist decides for himself what technic produces the film which he considers diagnostically most valuable. It is quite well known that different radiologists prefer different types of films for the same part of the human body.

These two problems form a stumbling block to the progress of scientific standardization of x-ray technic and it is obviously impossible to sweep them aside by choosing arbitrarily a machine and a technic which are to be called "best." Once more, the most effective procedure appears to be the accumulation and correlation of the data obtained by many men in an effort to find out the opinions of the majority and the merits of these opinions.

CONCLUSIONS

It is hoped that a large number of radiologists will attempt to employ the tests described for two purposes: (1) To aid them in controlling variations within their laboratory which cause them difficulty in diagnosis; (2) to collect data which may be analyzed for the purpose of standardizing radiographic technic.

In connection with this last purpose one more simple experiment might easily be put into effect. It is generally possible to arrange that the x-ray beam directed to about one square inch near a corner of each film be unobstructed. A two-step aluminum ladder, with steps ¼ and ¾ inch thick, can be fixed in position in the cassette holder over the area of the film. For every radiograph which is taken, there will be a record of density and of contrast in terms of these aluminum step thicknesses which may be compared with other films. This comparison may be made not only between films of a given type taken in one laboratory, but the results of several laboratories may also be compared. The analysis of the electrical problems concerned with radiography would be considerably facilitated by the collection of such data from a number of laboratories throughout the country.

PATHOGENESIS OF ACUTE SILICOSIS[1]

By R. POMERANZ, M.D., NEWARK, NEW JERSEY

FROM a series of a hundred cases examined, this study is based on the autopsy findings of five cases from two pulverizing plants in New Jersey, all cases showing acute silicosis or silico-tuberculosis. Further, this paper includes a short résumé of experimental data derived from the exposure of guinea pigs to the silica dust obtained from the above-mentioned plants.

In these plants large machine-driven mills are used for the grinding of the stones. Both white and colored men, working ten hours a day, are employed; their duties, apart from the actual work, include the cleansing of the machines and the tapping off of the walls, to remove any adherent dust. A further hazard is experienced in the bagging rooms, where dust is unavoidably thrown into the atmosphere from faulty bags. The dust masks which are provided are used by the workmen more as ornaments than as protection. The ventilation system is poor. The manufactured silica powder is of such fine quality (a large percentage of its particles being smaller than a micron) that it is used as an adjunct in scouring powders and cleansing pastes.

Duration of Exposure.—From the hundred cases examined, 15 were white men, three were colored women, and the rest were colored men. The time of exposure ranged from three months to three years. The superintendent, a white man, though working there for a number of years, was less exposed than the others (Fig. 1).

Fig. 1. Interstitial and nodular fibrosis, 5 years' exposure.

Fig. 2. Acute interstitial and nodular fibrosis, one and one-half years' exposure. (Plate by Dr. S. Greenwood.)

Chemical Analysis of the Powder.—Two samples of powder, containing 98.5 per cent free silica, SiO_2, and 0.5 per cent soluble silicates, were submitted for examination; the one labelled "coarse" showed a range of particles from two to twenty micra, and the

[1]Read before the Radiological Society of North America at the Eighteenth Annual Meeting, at Atlantic City, Nov. 28–Dec. 1, 1932.

other, "fine," showed a range from below a micron to three microns.

REPORT OF AUTOPSY CASES

Subjective findings common to all cases were shortness of breath (pronounced on exertion), loss of weight, non-productive cough, occasional pains in the chest (transient in nature), occasional night sweats, and rising temperature. Those cases complicated with tuberculosis had hemoptysis.

Clinical Findings.[2]—Restricted chest expansion, dullness over both hilus regions, rough breathing, with occasional râles over both central lung fields.

Case 1. G. V., colored male, 24 years old; worked in the plant one and a half years; date of x-ray examination May 8, 1929; date of death Jan. 4, 1930.

X-ray Findings (Fig. 2).—There is uniform fibrous infiltration of both upper lobes and of right base mesially. Both hili are enlarged and increased in density and are partly fused with the infiltrated areas of the lungs. Apices and bases are comparatively free, with no evidence of focal infiltration suggestive of tuberculosis. The infiltration in the involved areas of the lungs showed a network formation composed apparently of fused nodules.

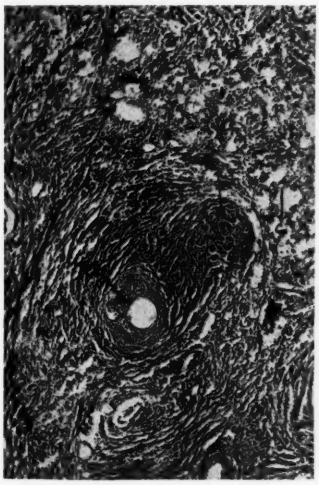


Fig. 3. Photomicrograph of tissue from case shown in Figure 2. *(A)* Central arteriole; *(B)* Silicotic nodule; *(C)* Thickened alveolar septa.

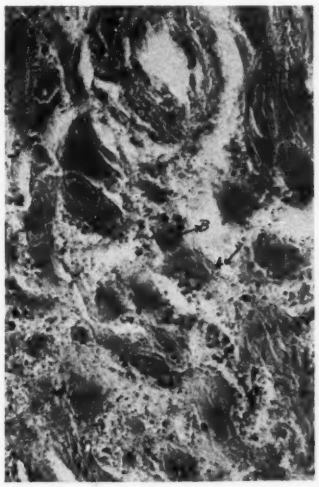


Fig. 5. Photomicrograph of an enlarged silicotic nodule with dust particles in the tissues. *(A)* Fine silica dust particles smaller than one micron; *(B)* Fibrous cells forming the silicotic nodules.

Autopsy Findings.—The left lung is large and well hardened by embalming. Over the posterior surface of the lower lobe is a small amount of fresh fibrin. The lung is of peculiar light brownish-gray color. On cut section it exudes a small amount of frothy but not blood-stained fluid; on pressure, the hilus nodes are large, some being three centimeters in size, and show, on section, the same brownish color. There is no tuberculosis of the lung, no primary effect, no reinfect. On close inspection of cut surface with hand glass there is seen to be marked fibrosis of the hilus, with grayish streaks radiating into the lung parenchyma. There

[2]Courtesy of I. Gluckman, M.D.

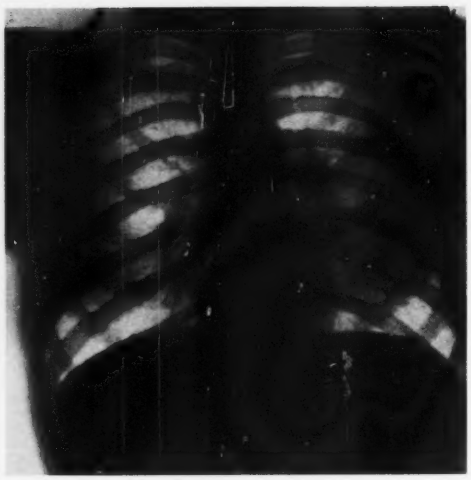


Fig. 4. Hilar infiltration (left), possibly due to reactivated tuberculosis after exposure to silica dust.

is no noticeable anthracosis present. The findings in the right lung are the same as in the left. Cause of death: acute silicosis.

Microscopic Findings (Fig. 3).—There is general interstitial and nodular fibrosis, with accumulation of dust particles, smaller than a micron in size, in the nodules. Most of the latter are fused with the neighboring ones to form large units. The fibrous nodules show different stages of regressive hyaline changes, and are situated as a rule around the small arterioles. Small lymphocytic infiltration can be seen around the nodules and the bronchi. No anthracotic pigment can be noted in the septa. The alveoli between the nodules are either compressed or widely dilated. The interstitial septa are thickened.

Case 2. J. M., colored male, 20 years old; worked in the plant fourteen months; date of x-ray examination Aug. 17, 1929; date of death, May 1, 1930.

X-ray Findings (Fig. 4).—There is marked enlargement of the left hilum shadow, with increased markings radiating centrally. The rest of both lung fields is free. The findings are suggestive of an early hilar infiltration, probably of tuberculous origin.

Fig. 6. Advanced hilar and nodular interstitial fibrosis, 3 years' exposure.

Autopsy Findings.[3]—Left lung: "Carnified adhesions over both pleural cavities. Large cavities in left upper lobe. Hilus nodes enlarged and of a mottled bluish-gray color. Left upper lobe is almost entirely destroyed by a large cavity six inches in size, composed of grayish eroded masses of lung tissue in which the section of bronchial tree and pulmonary vessels, many of which are thrombosed, can be seen. Upper part of lower lobe shows numerous discrete communicating cavities, one-half to one inch in size, with a grayish chronic exudative and acinous tuberculosis." Right lung: "The whole upper lobe is solid with chronic productive acinous tuberculosis, and with a small cavity formation. Middle lobe is the same. Lower lobe shows discrete areas of chronic tuberculosis. Cause of death: pulmonary tuberculosis, silicosis."

Microscopic Findings.—These are characteristic of caseating tuberculosis. Hilus nodes are packed with silica dust particles (Fig. 5).

Case 3. J. M., colored male, 52 years old; worked in the plant three years; date of x-ray examination Aug. 16, 1929; died early in 1930. Specimen of the lungs for histologic examination was sent to Dr. Martland.

X-ray Findings (Fig. 6).—There is sym-

[3]Courtesy of H. S. Martland, M.D.

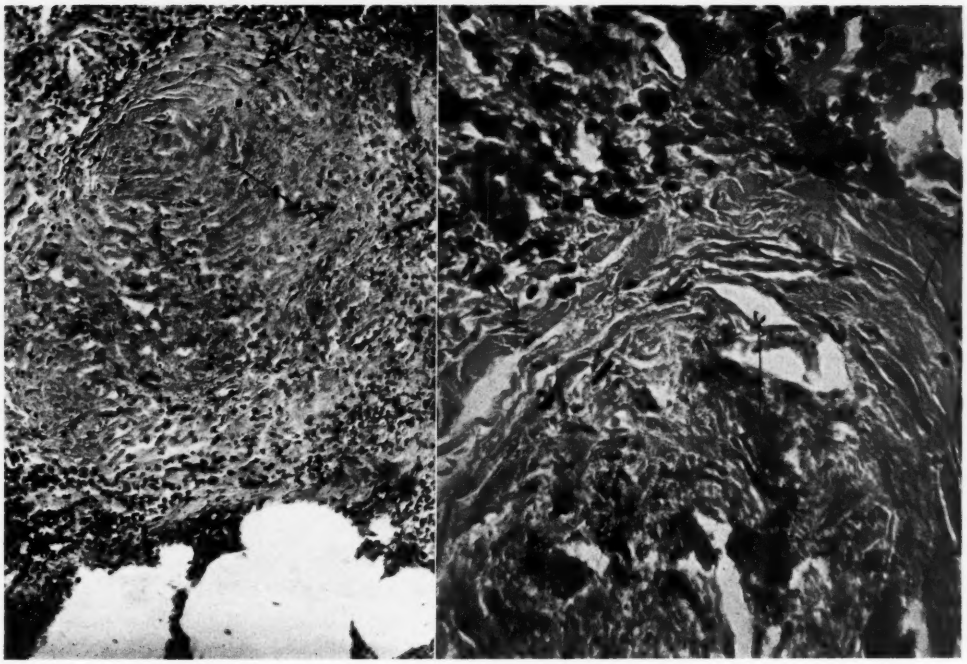


Fig. 7. Photomicrograph of tissue from case shown in Figure 6. Note anthracotic pigment around nodule. *(A)* Silicotic nodule; *(B)* Anthracotic pigment.

Fig. 9. Photomicrograph of border of a nodule surrounded by anthracotic pigment. Note difference between dust particles and surrounding pigment. *(A)* Anthracotic pigment; *(B)* Fibrous wall of nodule; *(C)* Silica dust particles.

metrically general fibrous infiltration of both lung fields, more pronounced at the left base. The hili are enlarged and increased in density. The pulmonary markings are dense, showing nodular infiltration with network formation. The diaphragm shows restricted respiratory movements. Apices are free. The bases show increased aeration.

Microscopic Findings (Fig. 7).—There is fibrosis similar to that in Case 1, with anthracotic infiltration of the interstitial septa. There is no evidence of tuberculosis.

Case 4. J. McC., colored male, 27 years old; worked in the plant two years; date of x-ray examination Jan. 15, 1930; date of death May 14, 1930.

X-ray Findings (Fig. 8).—There is general, mostly interstitial, fibrosis of both lungs, more pronounced on the right side. Both hili are increased in density. Apices and bases are free.

Microscopic Findings (Fig. 9).[3]—There was present nodular and interstitial fibrosis, as in Cases 1 and 3.

Case 5. G. McR., colored male, 50 years old; worked in the plant for two years; date of x-ray examination Nov. 13, 1929; died in 1930.

X-ray Findings (Fig. 10).—There is infiltration of the upper third of the right lung field extending towards and involving the right hilum. Increased fibrous markings extend towards the right base and the left central lung field. The left side of the diaphragm is elevated. There is an aortic shaped heart.

Microscopic Findings (Fig. 11).[3]—There was present fibrous tuberculosis of the right

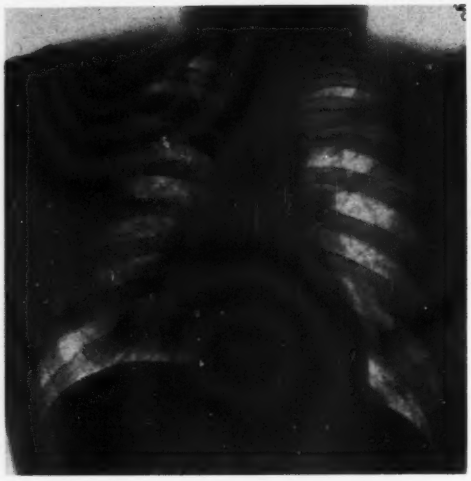


Fig. 8. Advanced interstitial and hilar fibrosis.

upper lobe, with silicotic nodular and interstitial fibrosis of the other lobes.

CHEMICAL ANALYSIS OF LUNGS IN CASES OF SILICOSIS[4]

Control	Ash in Dry Lung	Silica in Ash	Silica in Dry Lung
Female	4.03%	7.75%	0.31%
Male	5.1 %	13.00%	0.66%
J. M. (Case 2)	6.59%	37.20%	2.45%
J. M. (Case 3)	8.01%	40.60%	3.29%
J. McC. (Case 4)	6.17%	29.30%	1.81%
G. McR. (Case 5)	6.94%	30.30%	2.10%

Comment on X-ray Findings.—Commenting on the above five cases, the x-ray findings show an advanced stage of fibrosis, except in the instance of Case 2. Referring to Cases 1 and 3, both of which showed nodular infiltration, a differential diagnosis of disseminated tuberculosis comes to an issue. It will be noted that the shadows in chronic tuberculosis are, as a rule, changeable in size in the same individual and are irregularly distributed, whereas those in acute silicosis are more symmetrically distributed and are rounded rather than stellate. In the silicotic cases the apices and bases show the least involvement on the x-ray films. Furthermore, I am of the opinion that a small part of the interstitial fibrosis evident at autopsy cannot be visualized on a film, due to the physical property of the organ.

[4]Courtesy of Dr. Gershenfeld.

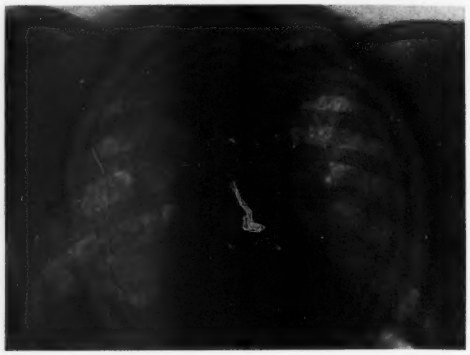


Fig. 10. Fibrous tuberculosis, right upper lobe, with acute interstitial fibrosis, 2 years' exposure.

Case 2 illustrates a rapidly re-activated tuberculosis as a result of exposure to the silica dust.

The first signs in an early involvement (Fig. 12) are enlarged and dense hili, usually symmetrical on both sides. The x-ray film alone, in this phase, is not conclusive of the diagnosis, unless supported by a history of exposure to silica dust, due to the fact that the appearance of a normal hilum shadow is still a moot question. In the tuberculous hilum we usually find the more predominant involvement of one side, together with irregular calcifications.

The next phase in the x-ray appearance (Fig. 13) is a uniform haze of the central lung fields, together with enlarged and dense hilar shadows. This, in my opinion, is strongly suggestive of an acute occupational fibrosis predominantly interstitial. These findings, together with a positive history of exposure to silica, lead to a definite diagnosis of early interstitial silicosis. In the further progress of interstitial fibrosis a fine network of pulmonic markings can be seen on the plate with uniformly distributed nodules, as above described; some single, some

fused. As the fibrosis progresses further we see the nodules scatter symmetrically in both central lung fields, occasionally more pronounced on the right side. They are numerous, from pin-head size to the size of the head of a match. The apices are usually free. The bases often show increased aeration due to compensatory emphysema.

In two of our cases we were able to follow the progress of the fibrosis by subsequent x-ray examinations. The first of these was W. V., colored male, 56 years old, father of G. V. (Case 1 above). He worked in the pulverizing plant with his son for about a year and a half and gave up his occupation in 1928. He was given an x-ray examination in that year (Fig. 14) and again in April, 1932 (Fig. 15). While the findings on the first plate resemble those of his son, the second plate shows large concretions of fibrosis, with shrinkage in the upper lobes. It would be difficult to rule out tuberculosis from the second plate alone. He is in a fairly good clinical condition, except for dyspnea on the slightest exertion. A similar progress of the fibrosis can be observed in the second case. The patient is a mechanic, N. E., white, male, 59 years old,

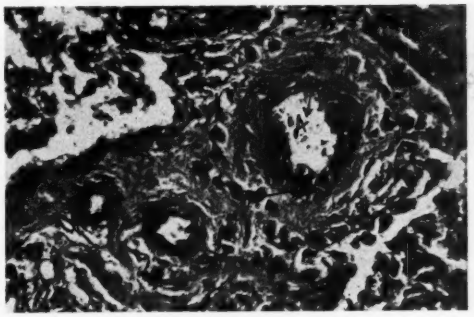


Fig. 11. Photomicrograph showing formation of nodular fibrosis around small arteries. *(A)* Arterial wall; *(B)* Fibroblasts.

who worked in the plant for ten months, repairing the machines. During that time he was exposed to a massive dose of the dust to such an extent that in this relatively short time he developed such a pronounced interstitial fibrosis (Fig. 16) that he was unable to continue his work. He was given an x-ray examination again nineteen months later (Fig. 17), which film shows a marked progress of the hilar and interstitial fibrosis corresponding with the increased dyspnea of the patient.

Any of the above described phases of fibrosis may be associated with tuberculo-

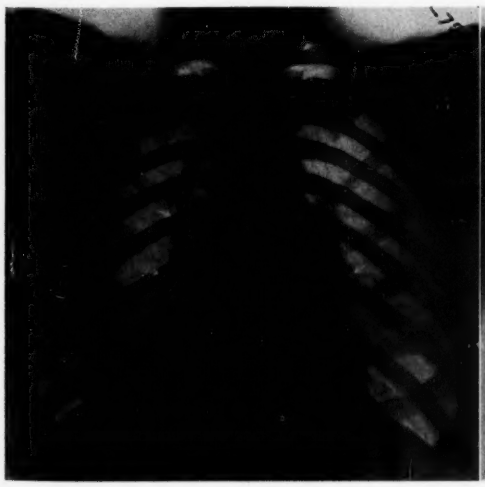


Fig. 12. Hilar enlargement, with early interstitial fibrosis.

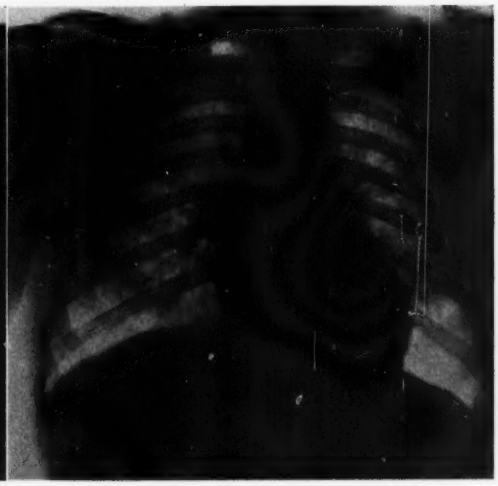


Fig. 13. Haze over central lung field indicating interstitial fibrosis.

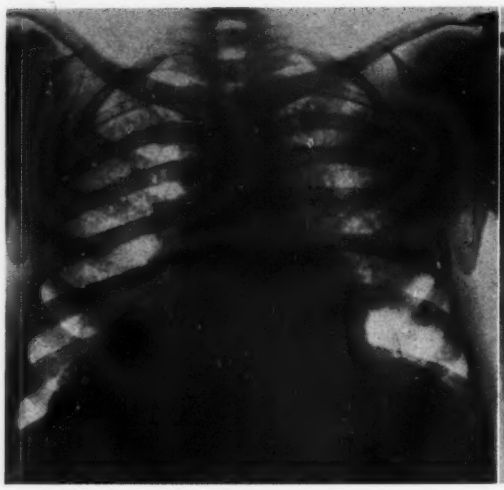


Fig. 14. Advanced interstitial and nodular fibrosis, one and one-half years' exposure. (Plate by Dr. S. Greenwood.)

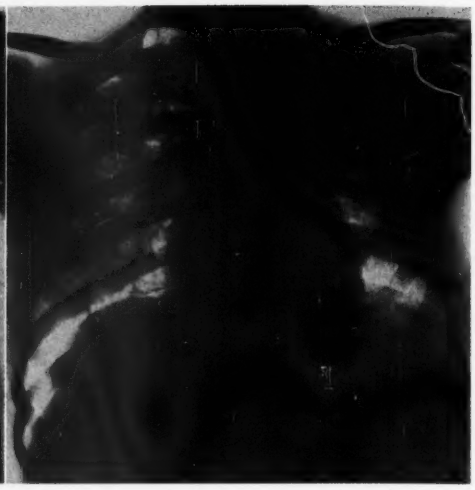


Fig. 15. Same patient as shown in Figure 14, four years later. Note progress of fibrosis after cessation of exposure.

sis, either active or inactive. The former could be seen in the form of apical cavities, with focal infiltration, soft in appearance, or in the form of a less active fibrous tuberculosis involving the upper part of the lung field. Sometimes only calcifications can be seen either in the hilum or in the lung fields, indicating an inactive type of the associated tuberculosis. The interesting findings of a reactivated tuberculosis as a result of exposure to silica dust was referred to above in Case 2.

Microscopic Findings.—In a typical case the predominant feature in the histologic findings is the interstitial fibrosis, with formation of silicotic nodules from 2 to 3 millimeters in size, of a laminated fibrous structure, situated around the central arte-

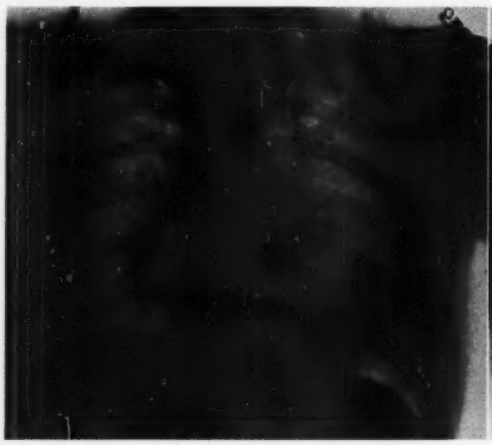


Fig. 16. The patient is a mechanic with 10 months' exposure. Note advanced hilar and interstitial fibrosis.

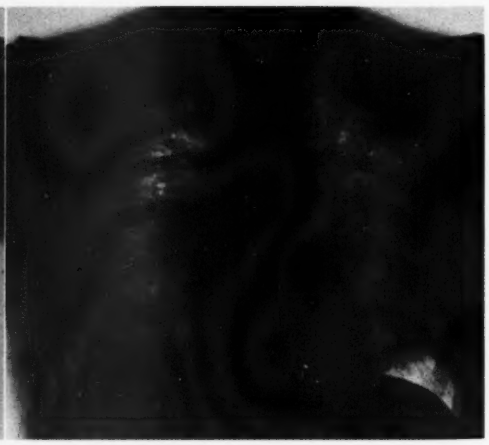


Fig. 17. Same patient as shown in Figure 16, 19 months after cessation of the 10 months' exposure. Note progress of the process.

riole. Some of them are single, while others are fused together to form large complexes of fibrous tissue. In the nodules residual elastic fibers can be seen. Most of the nodules are packed with silica dust particles less than a micron in size. The interstitial septa between the nodules are thickened, while the alveoli are compressed. Round-cell infiltration can be noted around the vessels and around the bronchi. The areas of the lungs which are not fibrosed show thin and widened alveoli, due to compensatory emphysema. The above-described findings of pure silicosis may be modified by anthracotic pigment, situated around the nodules (cf. Case 3).

We wish to point out that the silicotic nodules are situated around the arterioles as a rule. We will elaborate on this subject later, describing the results gained through our experiments.

Correlation of X-ray and Microscopic Findings.—It is evident that the early phases of fibrosis causing enlargement of hilar nodes due to excessive drainage and blockage of the lymph centers, will be visualized easily on the plate by the enlarged hilar shadows. However, the early interstitial fibrosis can be recognized first by the above-described haze over a part of the central lung fields, which is accompanied by an increase in pulmonic markings. It can be understood easily from the description of the microscopic findings that the interstitial fibrosis is a very fine process and that parts of the fibrosed lung tissue are superimposed over parts of over-aerated lung tissue. That explains why, when projected on the x-ray plate, part of the fibrous pulmonic tissue is lost and overshadowed by the over-aerated pulmonic structures. Therefore, as I stated above, a part of the interstitial fibrosis is lost in the projection. That is, an x-ray film (of even an advanced case) of the fine interstitial fibrosis does not do the subject justice, which means that in interpreting films of this character we have a right to conclude that the actual interstitial fibrosis is comparatively more advanced than visualized on the plate. We do not see the smallest nodules; we see only the larger ones caused by fusion of several smaller nodules.

Fig. 18. Box in which Guinea pigs were exposed. The dust was kept in suspension by a motor-driven agitator.

EXPERIMENTAL DATA[5]

A number of guinea pigs were subjected for six hours a day for a period of twelve weeks to the fine dust. Placed in a box (see Fig. 18), they were exposed to the dust, which was kept in suspension by means of a motor-driven shaker. After such exposure, they were fed and allowed to run in a normal manner.

Animal No. 1 was autopsied four weeks

[5]Preliminary report.

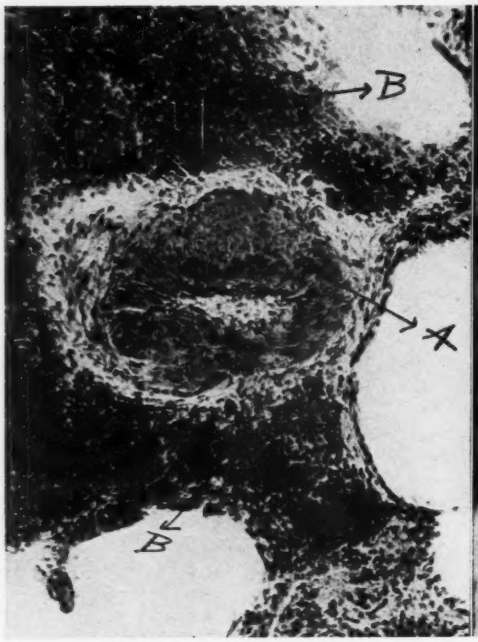


Fig. 19. Photomicrograph of tissue of Guinea pig No. 1, bronchopneumonic type of interstitial infiltration. *(A)* Large artery; *(B)* Interstitial pneumonic type of infiltration.

Fig. 20. Photomicrograph of tissue, Guinea pig No. 2, fibroblastic infiltration around an arteriole. *(A)* Wall of arteriole, cut obliquely; *(B)* Fibroblasts.

after exposure. At that time the gross findings in the lungs were several patches of infiltration, which microscopically showed a bronchopneumonic type of interstitial infiltration, mostly around the large bronchi, consisting of large mononuclear cells (Fig. 19).

Animal No. 2 was autopsied after ten weeks of exposure to the dust. Grossly there were only white streaks found in some of the lobes, microscopically seen to consist of a large mononuclear fibroblastic infiltration around the small arterioles (Fig. 20).

Animal No. 3 was autopsied four months after exposure had ceased. It will be noted from Figures 21 and 22 that the process of nodule formation has not only started but shows in the former a progress, inasmuch as one can see the central arteriole with periadventitial infiltration, thickening of the intima, together with splitting of the arterial wall. In Figure 22 one can see a cellular nodule with a peripheral, thickened arteriole.

Animal No. 4 was autopsied eight months after the exposure had ceased. In Figure 23 one sees a number of nodular formations, similar to those described above, scattered irregularly through the lung. It is to be noted that in practically every case the infiltration is around either a peripheral or central arteriole.

Animal No. 6 was autopsied twelve months after the exposure had ceased. The nodules are scattered over both lungs irregularly. The fibroblastic cells are smaller and of increased density, indicating a progress in the fibrosis.

A number of rats were also used in the experiments. By means of intravenous injection of suspended silica sand, each rat

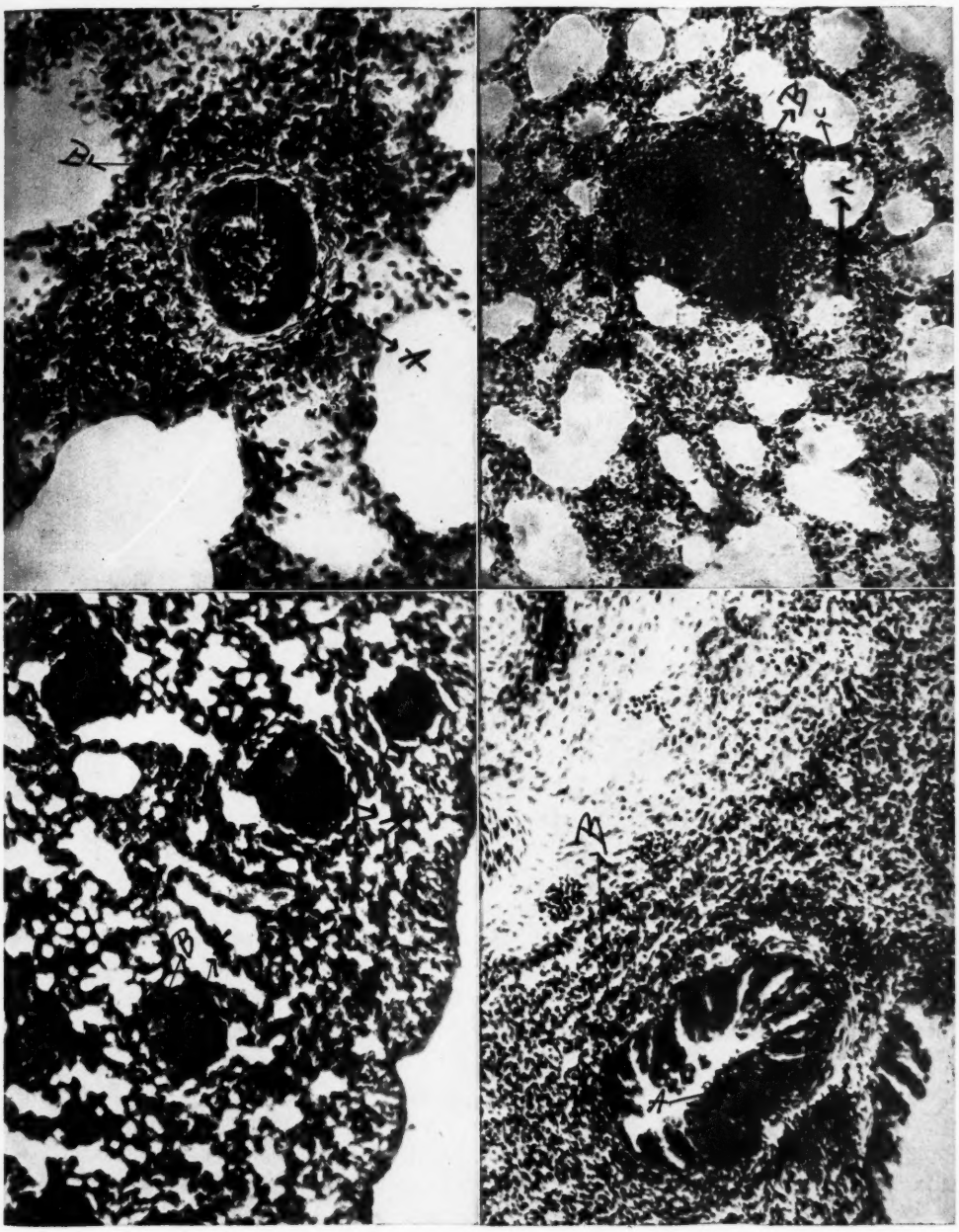


Fig. 21 *(upper left)*. Photomicrograph of tissue, Guinea pig No. 3, central arterial with periadventitial infiltration and splitting of arterial wall. *(A)* Thickened arterial wall; *(B)* Fibroblastic infiltration.

Fig. 22 *(upper right)*. Photomicrograph of tissue, Guinea pig No. 3, cellular silicotic nodule with peripherally thickened arterial wall. *(A)* Peripheral arteriole; *(B)* Cellular silicotic nodule.

Fig. 23 *(lower left)*. Photomicrograph of tissue, Guinea pig No. 4, showing multiple cellular nodules with central or peripheral arterials. *(A)* Cellular silicotic nodules; *(B)* Arterioles located at the periphery of the nodules.

Fig. 24 *(lower right)*. Photomicrograph of tissue of rat, showing bronchopneumonia similar to that of Guinea pig No. 1. *(A)* Bronchus; *(B)* Lymphocytic and fibroblastic infiltration.

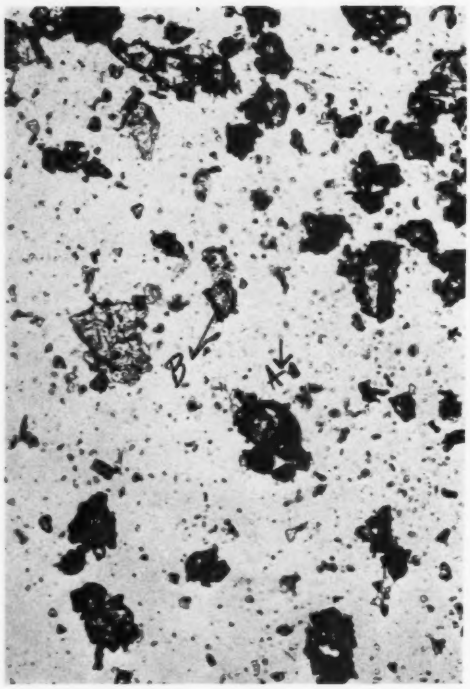


Fig. 25. Photomicrograph of silica particles to which both men and Guinea pigs were exposed. The coarse range from 3 to 20 microns (× 1,000). *(A)* Silica dust particles below one micron; *(B)* Coarse silica dust particles.

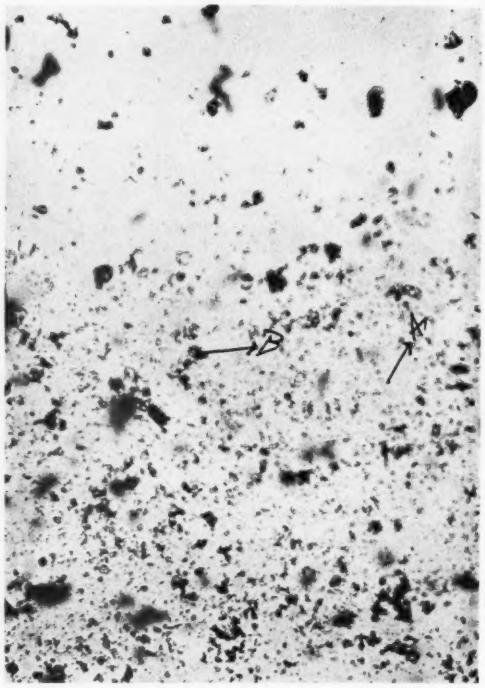


Fig. 26. Photomicrograph of silica particles to which both men and Guinea pigs were exposed. The fine range from 0.25 to 2 microns (× 1,000). *(A)* Silica particles smaller than one micron; *(B)* Silica particles larger than one micron. Note the relatively large amount of silica particles below one micron in this sample called "fine."

was given 2 milligrams of the fine variety per injection. Six injections were made for each rat over a period of eight weeks. It will be seen from Figure 24 that the lungs of those animals which were moribund following the third injection, showed an interstitial bronchopneumonia similar in every respect to that of Guinea pig No. 1. Eight months following the cessation of the injection several rats were autopsied; they showed bronchopneumonic foci in some places in an advanced stage of fibrosis, while in other places there was necrosis. There was no nodule formation and no interstitial fibrosis.

Correlating the above facts with the normal physiological conditions we know that the lining of the nasopharynx, and of the bronchi and bronchioli, is an efficient dust filter, so that the air which reaches the alveoli is practically dust-free. Under certain pathologic conditions, this situation changes. For example, the efficient dust filter of the upper respiratory tract is broken down by the small dust particles which produce infectious desquamative changes of the cells lining the bronchioli, impairing their function. This explains why a large amount of the dust reaches the alveoli.

The dust particles entering the alveoli are, in the case of workmen, partly expectorated in the sputum. The remaining larger part is phagocytized. The leukocytes carrying the dust particles—called dust cells—wan-

der through the lymphatics to the glands, some of them reaching the tracheobronchial glands. Due to the chemical and colloidal properties of silica many of the leukocytes are killed before they have reached the glands. When the overloaded lymphatic vessels become blocked they burst, throwing off the free silica into the perilymphatic spaces, accompanied by small arterioles. The dust particles, once deposited here, cause fibroblastic changes, with lymphocytic infiltration forming the early changes of dust granuloma, as shown by the experiments. They grow by additional fibroblastic infiltration, followed by regressive changes. The wall of the arteriole around which the dust granuloma has formed—later called "silicotic nodule"—constantly undergoes further regressive changes. A large proportion of the actual dust particles can be seen in the nodules.

From the above facts it is evident that only a part of inhaled silica dust can be eliminated, the bulk of it entering the alveoli and, phagocytized, stays both in the lungs and in the glands and continues its toxic (chemical and colloidal) effect on the tissues.

Further, we are of the opinion that the amount and size of the nodular formation is directly dependent upon the amount of silica inhaled. It is apparent that tuberculosis can complicate an interstitial fibrosis, but cannot be considered a primary factor in the formation of the fibrosis.

Summarizing the data obtained from both the experimental and autopsy findings, it has been shown how quickly an interstitial fibrosis can develop after a short but massive exposure to the finest dust of high free silica content, warranting the name "acute silicosis." Such a term is purely relative to the so-called chronic type which takes from three to fifteen years to develop. The term "acute" is also warranted, for the reason that the once established fibrosis shows a rapid progress, even after cessation of the exposure.

CONCLUSIONS

1. X-ray and microscopic findings have been presented from a large series of rapidly developed interstitial fibrosis.

2. It has been shown that the silica dust particles below one micron and containing 98.5 per cent of free silica are deposited in the interstitial lung tissue and in the glands. The fibrosis should be considered as a defense reaction on the part of the body against the toxic (chemical and colloidal) properties of the silica which cause loss of vital lung capacity.

3. The experiments have shown the extent of the toxic action of the silica, especially on lung tissue. They have also shown that the fibrosis is progressive and irreparable, a fact which was also observed on the serial roentgenograms of the living subjects after they gave up their occupation.

4. Microscopic findings in one case (Case 2) and the x-ray findings in others demonstrate that acutely reactivated tuberculosis may result from exposure to silica dust.

5. Every patient with established silicosis should be compensated by law, the amount of the compensation to depend upon the extent of the involvement. In connection with this fact it may be mentioned that a great deal of work has yet to be done in establishing a proper classification of silicotic involvement in relationship to compensation.

6. No workman showing even the earliest signs of a beginning silicosis should be allowed to continue in the dust-laden atmosphere.

The author is greatly indebted to Dr. H. S. Martland and his laboratory staff for their generous help in the preparation of this material. He also wishes to express his appreciation to Dr. I. Gluckman for his co-

operation in regard to the clinical data in these cases.

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A NEW CONTRAST MEDIUM FOR USE IN UTEROSALPINGOGRAPHY

PRELIMINARY REPORT

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SEVERAL attempts had been made to visualize the cavities of the uterus and Fallopian tubes in roentgenograms, long before Rubin described his tubal patency test by means of transuterine insufflation. Douay (1) gives credit to Le Lourier, who, in 1912, was the first to test the possibilities of the procedure, using a solution of colloidal silver. Cary (2), in 1914, and Rubin (3), in 1915, working independently of each other, utilized a 10 per cent collargol solution. The roentgen plates were not entirely satisfactory, making them difficult to interpret, and the injected medium caused considerable irritation. For a number of years, no further similar research was published. In 1922, Duvergey and Dax (4) reported the injection of silver nitrate into the bladder for the purpose of visualizing a salpingovesical fistula. The delineation was excellent, but the instillation of this medicament into the peritoneal cavity is certainly undesirable. Kennedy (5), in 1923, and Schober (6) later advocated the use of 20 per cent sodium bromide. The films thereby secured were good, but the chemical excited severe reactions, so that this method was soon discarded. Stone (7) tried 1-1000 hot bichloride and iodine (no percentage stated) for the transuterine determination of tubal patency and corroborated his findings by laparotomy. In England, Williams and Reynolds (8) employed emulsions of barium sulphate and bismuth, respectively, taking films 24, 48, and 72 hours later. The results, insofar as visualization was concerned, were excellent, but the method proved impractical because of non-absorption of the contrast medium and the pathologic changes which followed.

It was not until 1925 that the use of iodized oils was suggested. Carlos Heuser (9) reported his results at that time, although he had experimented with the medium during the previous four years. He was followed by Vercesi (10), Jaroschka (11), Rubin and Bendick (12), Schneider and Eisler (13), and thereafter many others became advocates of the method. The films were a decided improvement and not only were tubal patency and peristalsis determined, but some other pelvic conditions as well. Finally it was utilized as a therapeutic measure. Two films were taken at the time

Fig. 1. Normal uterine cavity with patent Fallopian tubes. A, A. Spill of contrast medium into pelvic cavity.

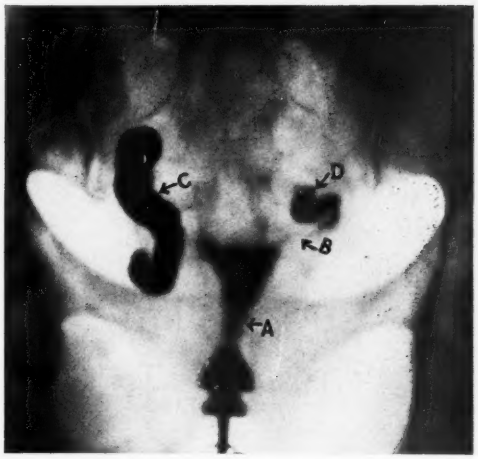

Fig. 2. Chronic bilateral salpingitis with left hydrosalpinx. Both tubes closed (checked by laparotomy). A, A. Normal isthmical portions of the Fallopian tubes; B, B. Dilated terminal portions of the tubes; C. Cervix. The small dark scattered areas are remnants of bismuth luteal injections.

of injection and a third 24 hours later. Peritoneal irritation was not mentioned in the early papers describing this method.

In 1927, Zimmerman and Nahmmacher (14), Odenthal (15), and Hoffman (16) discussed the possibility of danger from the used of iodized oils. Histologic examination of tubes excised 24 hours after the procedure did not disclose intrinsic pathologic alterations, but the peritoneum showed leukocytic infiltration and strands of fibrin. Temperature reactions were observed at times, but subsided quickly. Albano (17) reported a case of calcification of the retained mass in the tube months after the injection (Verkalkung des Breies). Rubin (18) reported abscess formation in two cases and peritoneal irritation in three cases. Mathieu (19) reviewed the contra-indications, but failed to mention any untoward results. Jarcho (20) made a critical review of the literature as well as of his personal cases and concluded that in selected cases the method is without danger insofar as the use of iodized oil is concerned.

It is now well known that in some instances many months elapse before the radiopaque contrast medium is completely absorbed, in some as long as 15 months. It is not unlikely, therefore, that its persistence may be fraught with danger. For this and other reasons, certain clinicians have discarded uterosalpingography and rely upon the tubal insufflation test alone.

A review of the literature of the past two and one-half years reveals a number of case reports which are worthy of mention. Schroeder and Jacobi (21) had the opportunity to study the pathology of the uterus, Fallopian tubes, and peritoneum of 30 cases following the injection of iodized oils. They report that when extirpation was performed shortly afterwards (24 hours) no pathologic changes were found, but when done 10 or more days later definite tissue alterations were noted. In one instance, oil peritonitis was observed in and beyond the culdesac. The uterus, rectum, and tubes were matted together in an oily, pasty mass. Sections of the involved tissues showed leukocytosis with fibrinous exudate. They further report two other cases with identical changes in the endometrium and conclude that if too much

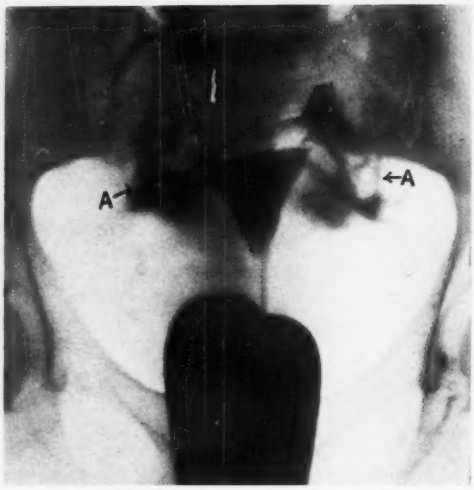

Fig. 3. Chronic salpingitis with right hydrosalpinx. A. Cervix; B. Isthmical portion of right Fallopian tube; C. Right hydrosalpinx; D. Droplet of contrast medium exuding from fimbriated end of left Fallopian tube.

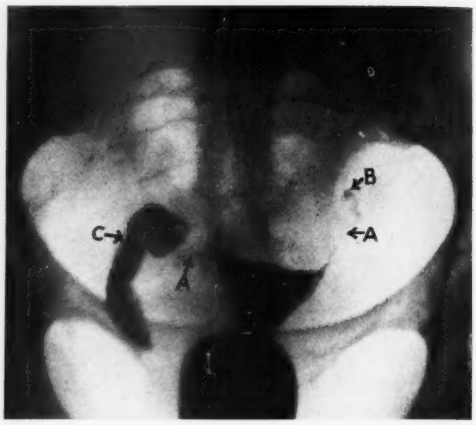

Fig. 4. Chronic bilateral salpingitis with right hydrosalpinx. Both tubes closed (checked by laparotomy). A, A. Isthmical portions of Fallopian tubes; B. Closure at the fimbriated end; C. Right hydrosalpinx.

of the iodized oil reaches the peritoneal cavity, there is always the possibility of "oil peritonitis." J. Novak (22) reports one case of foreign body inflammation *(Fremdkörper entzündung)* and two cases with resulting tubal calcification, in one of which the calcified tube had to be removed 15 months later. Hoffman (23) reports an instance of retention of the oil in a closed tube many months later. Schultze (24) reviewed 8,300 cases in which salpingograms had been made and found 30 with inflammatory changes and 250 with other complications. Gajzago (25) reports a death from oil embolism, corroborated by autopsy. Wong, Wu, and Chein (26) report four cases of escape of the iodized oil into the utero-ovarian venous system. They state that dogs have died after the intravenous injection of increased amounts of iodized oil.

The possible deleterious effects of iodized oil injections justify the search for another medium which will obviate these untoward results. To accomplish this purpose, the radiopaque mixture must possess at least five important features: (1) have a viscosity similar to that of oil; (2) be rapidly absorbed and excreted; (3) be non-injurious when entering the circulation; (4) render good delineation of the cavities of the pelvic organs, and (5) cause no pathologic changes in the tissues.

Recently we have used Neo-Iopax (Uroselectan-B) in a series of 18 patients. This chemical is a pyridine derivative with 51.5 per cent iodine in close organic combination. Up to the present time this medium has been found to comply with the specifications enumerated above. Experimenting with different percentage solutions, a 50 per cent mixture with glucose apparently yielded the best results. The cases were carefully selected; in those in which acute or subacute infection or pregnancy was present, the procedure was not used. The time chosen, when possible, was the intermenstrual period. Nervous patients were given a hypodermic of morphine gr. 1/6 half an hour before administration.

The bladder and rectum are evacuated and a douche given. The patient is placed on the x-ray table in the lithotomy position. After inserting a vaginal speculum and bringing the cervix into view, the vagina,

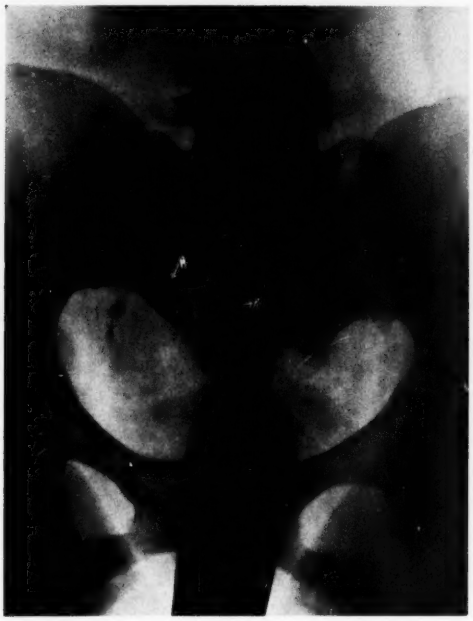

Fig. 5. Fibroid uterus. Left Fallopian tube closed at cornual end. Right Fallopian tube closed at fimbrial end. A, A. Enlarged uterine cavity with irregular outline denoting hyperplastic endometrium. B. Dilated fimbrial portion of right Fallopian tube.

cervix, and cervical canal are carefully swabbed with a solution of 3.5 per cent iodine. The posterior lip of the cervix is grasped with a vulsellum and the cervix steadied. A cannula with a flexible metal tip is then inserted into the external os. A syringe is attached to the open end of the stop-cock. About 10 c.c. of the solution are used, although the amount varies slightly with each patient. At the beginning, about 5 c.c. are injected slowly, stopping when pain begins. A film is exposed and then the remainder is carefully introduced. The cannula stop-cock is closed to prevent reflux and the syringe is removed. The speculum is then removed from the vagina, care being taken not to disturb the cannula. Another film is exposed. The instruments are removed, the vagina swabbed clean, and a flat plate taken. The patient returns about 90 minutes later and another exposure is made. If the fourth plate still shows presence of the solution, an interval of from 10 to 15 hours is allowed to elapse, and a fifth film is exposed.

Fig. 6. Senile atrophy of the uterus. The uterine cavity is small and the Fallopian tubes are closed at the cornual ends.

Results.—In one case in this series there was a temperature reaction of 102°, which was later found to be due to an intravenous salvarsan injection having been given the same morning. The temperature of all the other patients was normal. Occasionally complaint of slight pain was made, but this disappeared after the removal of the cannula, with reflux of the medium. None of the patients was incapacitated. In the majority of cases the contrast medium completely disappeared within 90 minutes. In the remainder, the 15-hour plate showed complete absorption. In all cases outline of the uterine cavity and the patency of the tubes were determined. In some, the findings were checked by laparotomy. A review of the sectioned specimens will be included in a second communication.

CONCLUSIONS

In all cases, even with a solution as low as 20 per cent, the uterine and Fallopian cavities have been visualized to a diagnostic degree. The 20 per cent solution is not sat-

isfactory for demonstration purposes, the 33 per cent is more satisfactory, and the 50 per cent solution is best.

There are two features which are particularly important. The opaque mixture is absorbed within 90 minutes in the majority of cases, and this suggests the problem of a physiologic degree of absorption from the graphic roentgenologic standpoint. Several cases in this series show the interesting phenomenon of apparent impregnation of the uterine endometrium by the contrast medium, and indicate the need for further study of the detailed anatomy and pathology.

We wish to record our appreciation to Walter T. Dannreuther, M.D., for his kind co-operation.

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THE THOMS' METHOD OF X-RAY PELVIMETRY AND CEPHALOMETRY

A DISCUSSION OF THE ADVANTAGES AND CASE REPORTS

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THE advantages of the Thoms' method of roentgen mensuration of the pelvic inlet and the fetal head *in utero* are so striking that it seems deplorable that they should be ignored by men who are striving to better obstetrical practice. These methods have been at the disposal of the profession for several years, yet the majority of practitioners who are doing obstetrics apparently overlook scientific methods which, if generally adopted, will be an important factor in the lessening of our fetal and maternal mortality. The reason for the indisposition of the profession to accept new methods seems to be characteristic of medical practitioners everywhere. Indeed, in obstetrical practice, the great tendency is to regard pregnancy and labor as normal physiologic functions which need no precise methods of diagnosis for their management.

It is the purpose of this paper to point out the important rôle that roentgen pelvimetry and cephalometry must assume if the management of every-day obstetrics is to be bettered. It seems to be a widespread conviction among obstetrical practitioners that if certain external measurements of the pelvis are within normal limits, the pelvic inlet or superior strait is likewise of normal proportion. It is, however, a fact that x-ray pelvimetry is constantly showing varying degrees of contraction of the pelvic inlet, even within the limits of so-called normal external pelvic measurements. At the present time, when instrumental interference seems to be on the rapid increase, the failure to recognize these contractions of the pelvic inlet is responsible for many cases of maternal injury and fetal death. It has been repeatedly shown that x-ray mensuration of the pelvic inlet by the Thoms' method will give an actual representation of this plane in its true proportions and will allow the mensuration of all diameters with a fraction of error within one-quarter of a centimeter. If we compare this information with the probability of error in the ordinary methods of external pelvic mensuration, we see at once the great advantages of the former procedure over the latter. It may be said, in this connection, that the only measurement in common use at the present time which gives useful information of a pelvic inlet diameter is that of the so-called conjugata diagonalis. However, even this determination may have a fraction of error as great as one centimeter, depending upon the thickness and inclination of the symphysis pubis. Furthermore, it is true that in many primiparous patients, because of a small outlet or a thick, rigid perineum, it is impossible, adequately, to determine the conjugata diagonalis. Many practitioners place a great deal of dependence on the external conjugata, or Baudelocque's diameter, as an index of the conjugata vera. However, the factor of error in this measurement is so great that most modern text-books agree that it is the most useless of all of the external measurements. It is my own opinion that Baudelocque's diameter should be placed among the relics of obstetrical history, for it has been my frequent experience that a normal and even supernormal conjugata vera is often present in combination with a markedly shortened Baudelocque's diameter. I have often found the conjugata vera to be as much as 12 cm. when the Baudelocque's diameter measured as little as 17 centimeters. Other external measurements usually

taken give only relative information and certainly do not give any idea as to the amount of transverse room available in the superior strait. Therefore, I have come to the conclusion that the only external measurements of real value are the direct measurements of the pelvic outlet and the measure of the conjugata diagonalis.

In addition to the true measurements of the superior strait, roentgen pelvimetry affords another type of information of that plane which has hitherto been unavailable, namely, the shape and symmetry of the pelvic inlet. It is surprising, the number of instances in which slight and often moderate asymmetry between the right and left halves of the pelvis is present, as demonstrated by roentgen pelvimetry. What influence such asymmetry has upon the position of the presenting part and the subsequent course of labor remains a subject for further investigation.

The Thoms' method of roentgen cephalometry may be said, for practical purposes, to be accurate enough for careful diagnosis. By the method one is able to determine whether the fetus is mature, premature, or over-size. In general, experience has shown that when the occipito-frontal diameter of the fetal head *in utero* measures 10.5 cm. or more, the infant will weigh safely over 5 pounds and can, therefore, be considered mature. When an occipito-frontal diameter of a vertex *in utero* measures over 13 cm. by x-ray cephalometry, the fetus can be considered over-size. Such a diagnosis in relation to a normal pelvis causes no alarm because molding of the vertex will take care of moderate fetal disproportion with progress of labor. The association of an over-size fetus with moderate pelvic contraction, on the other hand, with varying presentations and mechanical factors involved, gives rise to situations which heretofore no one has been able to evaluate except by intuition in the course of labor, sometimes too often prolonged. It will be seen at once that, with the knowledge of the size of the fetal head and of the size of the plane of the superior strait, the obstetrician is possessed of information which until the present time has been unavailable, and the lack of which is responsible for the management of many obstetrical cases in the hit-or-miss fashion so often ending in disaster.

It is not the purpose of this communication to review the technic of these roentgenometric methods. The original articles by Thoms are available to all who are interested, and references are given at the end of this paper. Briefly, the technic consists in determining the position of either the plane of the superior strait or the occipito-frontal diameter of the fetal head above the sensitized film, and then, after the initial roentgen exposure, superimposing a perforated square centimeter lead plate in this same plane, transferring measurements directly to the sensitized film by a second exposure. The measurements from the sensitized film can then be transferred to make a graphic record, known either as a pelvigram or a cephalogram, and may be filed as part of the permanent history record. In the accompanying charts such records are shown. The argument frequently brought forward that roentgen pelvimetry may injure the fetus or produce premature labor has been shown repeatedly to be absurd. The small percentage of the actual skin dose which is necessary for general roentgenograms should dispel the idea of injury of any sort. Furthermore, the use of aluminum filters obviates any danger which might occur to the skin of the patient.

The cost of the mechanical appliances necessary is very small in comparison to the usual expense of minor roentgen equipment. It is a relatively easy matter to train a technician to make roentgenograms routinely, although the technic seems a little involved at first. A satisfactory roentgenogram

should be obtained in each case within ten or fifteen minutes at the most.

My own experience with these methods has led me to the following conclusions with regard to their adaptation. I classify those patients who should have roentgen pelvimetry as follows:

1. All primiparæ in whom the conjugata diagonalis is shown to be 11.5 cm. or less.
2. All primiparæ in whom the vertex fails to become well engaged by the thirty-second to thirty-fourth week of pregnancy.
3. Any multipara who presents a history of previous difficult labor with an infant of normal size.
4. Any multipara who presents a history of fetal death subsequent to operative delivery from below.
5. Primiparæ with occipito-posterior or other abnormal presentation.

I have reached the conclusion that the following conditions should necessitate roentgen cephalometry:

1. Toxemia of pregnancy when termination of pregnancy means possibility of a premature fetus.
2. Pyelitis and cystitis which necessitate premature induction of labor.
3. Any condition in which the viability of the fetus is questioned.
4. Any condition which causes a suspicion of an over-size infant, when shortening of either the anterior-posterior or transverse diameter of the superior strait is present.

The above list may seem like a considerable number of indications for the use of this technic, but when it is realized that in actual practice these cases are comparatively few, the number does not seem so great. However, it is this very group of patients who collectively represent the larger percentage of those who are subjected to the dangers of fetal and maternal injury.

CASE REPORTS

The following case reports are illustrative of the great aid which the Thoms' methods have furnished in my practice and they are herewith offered, with a brief summary of each case, in order to illustrate these advantages.

Case 1. Mrs. P., a primipara, external measurements suggestive of a generally contracted pelvis. At the onset of labor the vertex was floating, with moderate overriding. Roentgen pelvimetry in the thirty-second week of pregnancy showed, however, a large pelvic inlet, anteroposterior diameter 11.25 cm., transverse diameter 13.5 centimeters. Labor occurred spontaneously following premature rupture of the membranes. A 6-hour labor followed, with delivery of an 8-pound baby in left occiput anterior.

Comment: Without the knowledge of the adequacy of the pelvic inlet this situation would have caused great concern. It proves again that many pelves which measure small externally show, by roentgen pelvimetry, a normal superior strait.

Case 2. Mrs. F., a primipara, external measurements practically normal, conjugata diagonalis not reached. Patient went into labor spontaneously at term. During the first stage of labor the vertex rotated from right-occiput posterior to persistent occiput posterior. A difficult mid-forceps extraction resulted in cranial injury to the fetus, death resulting within ten hours. Mother's recovery was uneventful, but, in explaining the obstetrical risk for further pregnancies, her physician stated that because of pelvic contractions, subsequent pregnancies should be terminated by Cæsarean section. The pelvigram shows a very large inlet, with a marked variation in the normal ratio between the transverse and anteroposterior di-

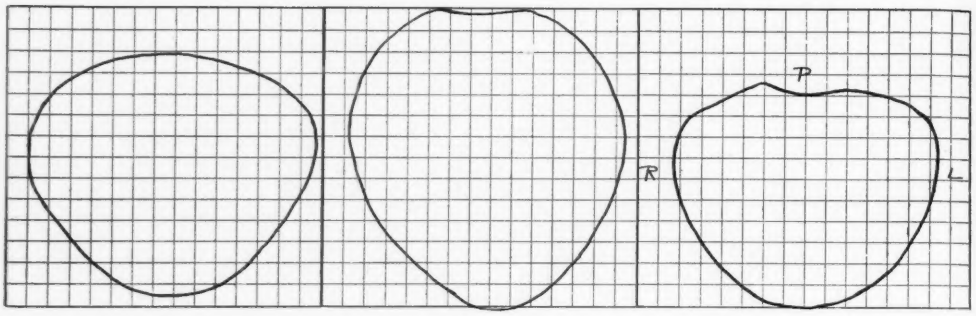

Fig. 1. Sup. str. A. P. 11.4 cm.; trans. 13.75 cm. External measurements: Sp. 22.5, Cr. 27, Tr. 30, D. B. 18, C. D. 11.5. Outlet: Bit. 8.5, A. S. 7, P. S. 8. Average stature; normal development.

Fig. 2. Sup. str. A. P. 14 cm.; trans. 13.25 cm. External measurements: Sp. 22, Cr. 26, Tr. 29, D. B. 17, C. D. N.R. Outlet: Bit. 8, A. S.——, P. S. 8. Average stature; very thin.

Fig. 3. Sup. str. A. P. 10 cm.; trans. 12.75 cm. External measurements: Sp. 24, Cr. 27, Tr. 30, D. B. 20, C. D. N.R.P. Outlet: Bit. 8.5, A. S.——, P. S. 8. Average stature; normal development.

ameter, making this pelvis almost of the justo-major type in spite of the small external measurements. One would suppose from this that the engagement and descent would be easy, but, as Thoms has recently pointed out, the occurrence of occiput posterior presentations is almost the rule in pelves in which the anterior-posterior diameter is larger than the transverse, as is illustrated in this case and in Case 7. In an individual possessing this pelvis, careful examination will usually reveal another pecularity, namely, that the plane of superior strait makes an abnormally steep angle with the horizontal. This condition has been described by Porter, who says: "In these cases of steep pelvis, engagement is difficult or sometimes impossible in the anterior positions, but easy in occiput posterior. Labor is difficult, however, because the axis of the uterus diverges posteriorly from the pelvic axis."

Figure 3 shows a pelvigram of a primipara with normal external measurements and an adequate transverse and anteroposterior diameter. Nevertheless, there is definite asymmetry in the sacro-iliac area, one side having a deeper curve than the other. In this instance the vertex did not engage until the onset of labor, but delivery was spontaneous in left occiput anterior.

Case 4. This case shows a greater exaggeration of the type described in Case 3. While the anteroposterior and transverse diameters are normal, there is marked flattening of the normal pelvic contour in both sacro-iliac areas. The patient was a primipara. The vertex did not engage up until the time of onset of labor but remained above the inlet. A trial labor was allowed for ten hours and, following this period, with good contractions, the cervix became only one-third dilated, with the membranes unruptured and the vertex remaining unengaged, with marked overriding. Delivery was terminated by Cæsarean section and a seven and three-quarters pound infant was born.

Case 5 illustrates another type of asymmetry of pelvic contour. This shows a pelvis which has a deeper curvature in the right sacro-iliac region than in the left, causing a marked difference in the oblique pelvic diameters. This patient had a difficult labor and instrumental delivery in right occiput posterior with her first pregnancy, resulting in a fetal death from intracranial hemorrhage. With her second pregnancy, labor was induced at eight and one-half months and terminated by an easy low forceps delivery in left occiput anterior.

Case 6 shows a pelvigram of a typical generally contracted pelvis. The patient was

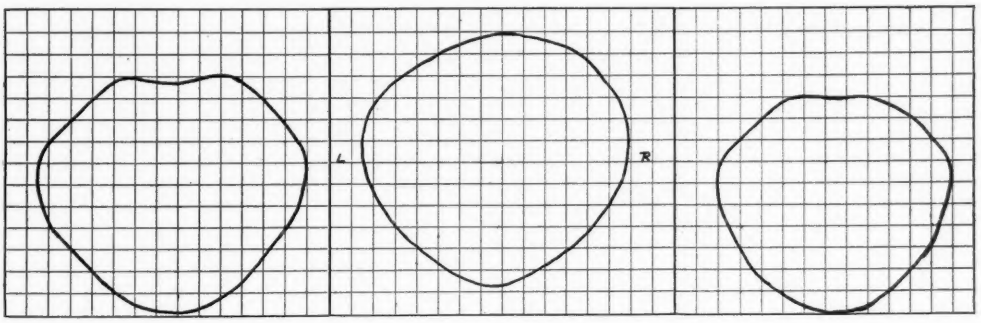

Fig. 4. Sup. str. A. P. 10.5 cm.; trans 12.5 cm. External measurements: Sp. 23, Cr. 27.5, Tr.——, D. B. 18, C. D. 11.5. Outlet: Bit. 8.5, A. S.——, P. P. S. 9. Short stature; normal development.

Fig. 5. Sup. str. A. P. 11.75 cm.; trans. 12.25 cm. External measurements: Sp. 26, Cr. 28, Tr. 30, D. B. 18, C. D. 12+. Outlet: Bit. 9, A. S. ——, P. S. 9. Short stature; normal development.

Fig. 6. Sup. str. A. P. 10 cm.; trans. 10.8 cm. External measurements: Sp. 20, Cr. 24, Tr. 28, D. B. 16, C. D. 10.5. Outlet: Bit. 7.5, A. S.——, P. S. 8. Short stature; normal development.

a primipara, 22 years of age. At term, the vertex was unengaged and there was evidence of real disproportion. A trial labor of six hours failed to show any diminution in the disproportion, and labor was terminated by Cæsarean section. The fetus was delivered alive, although the vertex was markedly molded from the trial labor and respirations had to be stimulated by carbon dioxide and oxygen before they were satisfactorily established.

Case 7 shows a typical transversely contracted pelvis similar to Case 3, the importance of which has been recently emphasized by Thoms. In this instance the fetus presented in right occiput posterior at the onset of labor. The patient was a negress and a primipara. She was allowed to progress to full dilatation during sixteen hours for the first stage, after which the vertex rapidly descended to the perineum in persistent occiput posterior. The patient was delivered by an interne with a low forceps operation and the third stage was completed without excessive hemorrhage. As the patient was recovering from the anesthesia, she suddenly went into a state of severe shock and, in spite of all efforts, she had complete circulatory failure within an hour from the time of the birth of the baby. The medical examiner's report stated that death was due to anesthesia. However, a check on the amount of ether used showed that only 3 ounces of this drug were administered by the open method. An autopsy was performed on this case to determine the cause of death and it was during this procedure that we were able to check on the accuracy of the x-ray pelvic measurements. This was done and showed that the pelvic measurements were accurate to an exact degree.

Case 8 shows a pelvigram of a flat rachitic pelvis in a rachitic negress, aged 21, a primipara. A marked deformity of this kind, of course, was obvious without roentgen pelvimetry. Cæsarean section was definitely indicated.

Cases 9 and 10 represent the same type of pelvis in two individuals and variations in the size of the child, in each instance, led to a different obstetrical situation. In Case 9, the patient, in her first pregnancy, went into labor with an occiput posterior presentation and, at the end of a long first stage of labor, pregnancy was terminated by a difficult Scanzoni extraction of a six and three-quarters pound baby. The external measurements of the patient were normal and the pelvigram (taken during the eighth month of her second pregnancy) showed a small, round pelvis. Despite the generally contracted pelvis, it was felt that the infant

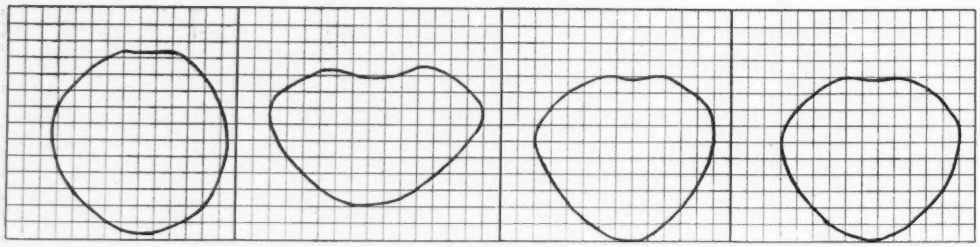

Fig. 7. Sup. str. A. P. 11.0 cm.; trans. 10.75 cm. External measurements: Sp. 24, Cr. 28, Tr. 29, D. B. 17, C. D. 11.5. Outlet: Bit. 8, A. S.——, P. S. 9. Normal stature; normal development.

Fig. 8. Sup. str. A. P. 7.75 cm.; trans. 13 cm. External measurements: Sp. 23, Cr. 25, Tr.-——, D. B. 17, C. D. 9.5. Outlet: Bit. 7, A. S.——, P. S. 8. Rachitic dwarf.

Fig. 9. Sup. str. A. P. 9.8 cm.; trans. 11.0 cm. External measurements: Sp. 24, Cr. 26, Tr. 30. D. B. 20, C. D. not reached. Short stature; normal development.

Fig. 10. Sup. str. A. P. 9.8 cm.; trans. 11.0 cm. External measurements: Sp. 24, Cr. 28, Tr. 30, D. B. 19, C. D. N.R. (tight perineum). Outlet: Bit. 9, A. S.——, P. S. 9. Short stature; normal development.

was small and, after a trial labor, satisfactory progress was noted, with again an occiput posterior position. The vertex rotated anteriorly spontaneously and pregnancy was terminated by low forceps extraction. The fetus weighed six and one-quarter pounds.

Figure 10 represents the pelvigram of a primipara who was first seen at the end of pregnancy. The pelvigram showed, as in Case 9, a small, round pelvis. A fetal cephalogram showed an occipito-frontal diameter of 12.75 centimeters. It was apparent that the patient had a generally contracted pelvis, with floating head and moderately large fetus. A trial labor was allowed for eighteen hours, with good contractions, but without any attempt at engagement of the vertex. Pregnancy was terminated by Cæsarean section, the infant weighing 8 pounds, 14 ounces. *Comment:* In both Case 9 and Case 10, the chief pelvic deformity rested in the shortening of the transverse diameter of the superior strait. In the first instance, the small baby allowed a successful labor through the normal channel. In the second instance, a large baby prevented the normal progress of labor, and the knowledge of the true pelvic measurements by means of roentgen pelvimetry suggested the proper time for interference by means of Cæsarean section.

The following case reports are appended to demonstrate the great value of fetal cephalometry *in utero*. As Thoms has pointed out, when the occipito-frontal diameter of the fetus *in utero* measures 10.5 cm. or more, the infant will weigh safely over five pounds and can, therefore, be considered mature.

Figure 11 is a composite cephalogram of two exposures of the same fetus, one at the seventh month and the other at the eighth month of pregnancy. The smaller cephalogram shows the vertex to have an occipito-frontal diameter of 9.25 cm., and the larger a diameter of 10.5 centimeters. The patient, a primipara, aged 40, was first seen at the fifth month of pregnancy and at the seventh month began to have edema, albuminuria, and hypertension. Under treatment, the patient improved, but a month later the condition became more aggravated and termination of pregnancy seemed advisable. The second cephalogram showed the occipito-frontal diameter to be 10.5 cm. and it was decided from this information that the infant was safely mature. A 5-pound, 12-ounce baby was delivered by Cæsarean section.

Figure 12 represents a cephalogram showing an occipito-frontal diameter of 9.5 centimeters. This patient also suffered during the first half of pregnancy with hypertension but with no other symptoms of toxemia. Shortly after the sixth month, however, she rapidly developed a nephritic toxemia and early in the seventh month her blood pressure was 210/120, with generalized edema and heavy albuminuria. The condition became more alarming and the termination of labor was imperative. The cephalogram showed the infant to be immature and a 4-pound, 9-ounce baby was delivered after the induction of labor by means of a Voorhees bag.

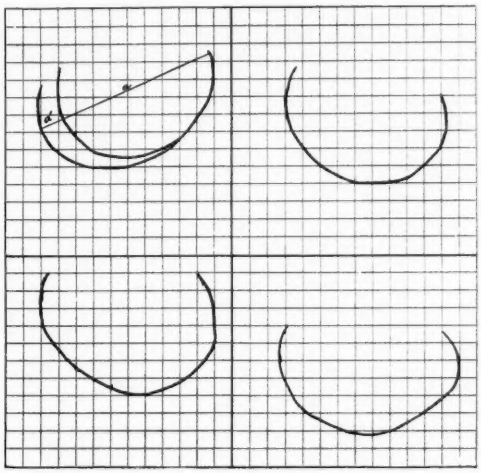

Fig. 11 *(upper left)*. a = 9.25; a + a′ = 10.5; at birth occiput frontal = 10.7.
Fig. 12 *(upper right)*. Occiput frontal = 9.5; at birth = 9.5.
Fig. 13 *(lower left)*. Occiput frontal = 10.5; at birth = 10.5.
Fig. 14 *(lower right)*. Occiput frontal = 10.4 cm.; at birth = 10.6 cm.

Figure 13 shows a cephalogram measuring 10.5 cm. in the occipito-frontal diameter. This patient was a para II, aged 35, and presented rheumatic heart disease with mitral stenosis. The first pregnancy aborted at five and one-half months following cardiac decompensation. She was first seen in the present pregnancy at the second month, at which time she was compensating fairly well. She did well until the sixth month at which time there was occasional evidence of edema at the bases of the lungs, but the cardiac reserve still seemed good. She was put at complete rest and for a month or so no further symptoms developed. At the seventh month, orthopnea began to be pronounced. Hospitalization was advocated and the cephalogram was then taken. From the findings of this procedure it was felt that the infant was safely mature and digitalization of the patient was begun and continued for ten days. A Cæsarean section was performed and a 5-pound, 10-ounce baby was delivered.

Figure 14 shows a cephalogram with an occipito-frontal diameter of 10.25 cm. The patient was a para VII, aged 40, who had undergone a previous therapeutic abortion at the second month for bilateral pyelitis and cystitis and a left renal calculus. She was seen during the present pregnancy at the fifth month, having been referred to the

hospital for another therapeutic abortion. However, examination showed the patient's general condition to be good, and it was the opinion of the medical staff that her condition did not warrant immediate therapeutic abortion. With treatment, the patient's condition remained unaltered until the seventh month of pregnancy, at which time she had a sudden onset of severe costovertebral pain and tenderness. Cephalometry was performed and the size of the vertex indicated that, in spite of the patient's estimation of seven months' pregnancy, the fetus was probably safely mature. Labor was induced by means of a Voorhees bag and a 5-pound, 4-ounce baby delivered.

In conclusion, I wish to say that the management of labor in cases in which roentgen pelvimetry shows pelvic abnormalities will, of course, provoke individual differences in the matter of treatment. However, the exact measurements afforded by this improved technic will allow more careful study of the advantages of various methods in the conduct of labor than is possible under the present unreliable information. The removal of the factors of uncertainty by the methods here emphasized must eventually affect our present obstetrical standards so that in the future we may look forward to the handling of obstetrical work with a more comforting certainty as to the outcome. When the obstetrician suspects that a patient presents a generally contracted pelvis, with a floating vertex, and the roentgenogram shows a normal inlet, he becomes fortified with knowledge which is of the greatest value. The use of the methods here emphasized also allows the more scientific use of the so-called trial labor, and of the induction of labor when necessary.

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THE ROENTGENOLOGIC DIAGNOSIS OF RUPTURE OF THE LIVER AND SPLEEN AS VISUALIZED BY THOROTRAST

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A REVIEW of the literature to date regarding the use of thorotrast reveals no report of its use or attempted use in the diagnosis of trauma of the liver and spleen. It has been used in the diagnosis of pathologic conditions affecting these organs, but not in traumatic surgery. All the cases recorded have been observed for some time and in many instances normal structures were found. In some cases the drug was administered to normal patients and in other cases animal experimentation served the observers' purpose. Herein, therefore, is presented what is believed to be the first case on record in the use of thorotrast in the diagnosis of traumatism of the liver and spleen.

CASE HISTORY

A colored male was admitted to the Alex-

andria Hospital, May 1, 1932, on the service of Dr. M. D. Delaney, Sr., as the result of an automobile accident. He was unconscious and from the physical signs and the testimony of his companions was in the state of acute alcoholism. Differentiation between surgical shock and alcoholic intoxication was impossible at this time. Expectant and supportive treatment was ordered until the next morning, when a more accurate diagnosis could be made. As the result of a thorough physical examination a diagnosis of intra-abdominal hemorrhage was made and the patient was operated upon twelve hours after admission, by Dr. Delaney.

Fig. 1 *(A* and *B).* Fragments from the lower pole of the spleen; *(C)* splenic artery seen entering the hilus; *(D)* semi-detached portion of the liver; *(E)* upper extremity of the stellate rupture of the liver.

At operation, a rupture of the jejunum was found, together with a stellate rupture of the quadrate lobe of the liver immediately to the right of the midline, and a rupture of the lower pole of the spleen. The intestine was sutured and the ruptures of the liver and spleen were packed. Closure with drainage completed the operation. During the operation the pulse varied from 126 to 160 and the respiration from 26 to 38. Saline solution, 1,000 c.c., and adrenalin m x v. were administered intravenously during the operation. The patient was returned to the ward in fair condition. A study of the accompanying chart (Fig. 1) shows not only the range of temperature, pulse, and respiration, but also the intravenous therapy including one transfusion.

The first injection of thorotrast, 14 c.c., was

Fig. 2. Reproduction of the radiograph after the injection of thorotrast, showing the multiple rupture of the spleen and liver.

given, without saline or glucose solution, 48 hours after operation. The second dose of the drug (24 c.c.) was given with 50 c.c. of normal saline solution, 96 hours after operation. A further study of the chart shows that there were no untoward reactions as a result of the administration of the drug. The packing in the liver and the spleen was removed in 48 hours and thereafter the patient drained fresh bile and a seropurulent exudate continually. Although strenuous supportive treatment was given, he was unable to overcome the peritonitis and died six days after operation.

ROENTGENOLOGIC REPORT

A stereoscopic study shows a marked dilation, with gas, of the entire stomach such that its complete outline is visualized and also the organs placed posteriorly to it. The spleen is placed in the left hypochondrium at the level of the eighth, ninth, tenth, and eleventh ribs. The splenic silhouette measures 14 cm. from the upper to the lower pole, and 9.5 cm. from the medial to the lateral border. The hilus shadow is 9.0 cm. from the lower pole. There is a curved indentation on the costal surface measuring 3 cm. in length and 7.5 cm. from the lower pole.

There is a multiple rupture of the lower pole of the spleen, such that a fragment of splenic tissue (Fig. 1-*A*) measuring 2.5 cm. in cross-diameters and involving less than one-half the thickness of the spleen, is displaced downward and lateralward and rests upon the splenic flexure of the colon and is supported by the sustentaculum lienis.

There is a second detached portion of splenic tissue (Fig. 1-*B*), fusiform in shape, lying partly behind the detached portion previously described, with its apex lateral to the lower pole of the left kidney and measuring 5 cm. in length and 2.5 cm. in breadth. There are corresponding deficiencies at the lower pole and on the renal portion of the visceral surface of the spleen. The splenic artery (Fig. 1-*C*) is seen entering the hilus.

The liver reaches from the dome of the diaphragm to within 2 cm. of the lower border of the tenth rib in the mid-axillary line. The left lobe of the liver is compressed into a narrow strip by the pressure exerted by the dilated stomach against the diaphragm. There is a stellate rupture of the antero-visceral surface of the right lobe of the liver in the parasternal line, involving the quadrate lobe on the visceral surface, such that a triangular area of the liver (Fig. 1-*D*) measuring 5 cm. in cross-diameters is depressed downward and is placed anterior to the pyloric end of the stomach, resting against the gastrohepatic ligament. The semi-detached triangular portion of the liver substance is the posterior portion of the quadrate lobe, extending medially from the fossa for the obliterated umbilical vein (ligamentum teres) to the fossa for the gall bladder laterally. The distally directed apex of the semi-detached portion is the displaced posterolateral angle of the quadrate lobe. The base of the semi-detached portion coincides to the midline of the quadrate lobe drawn transversely between the anterior and posterior borders. There is a corresponding deficiency on the antero-visceral surface of the liver, while the upper limb of the rupture extends well up on the anterior surface of the right lobe and is lost in the thickness of the liver (Fig. 1-*E*).

The left ureter is well seen crossing the tip of the transverse process of the second lum-

bar vertebra. There are rudimentary twelfth ribs measuring approximately 2.5 cm. on the left side and 4 cm. on the right side.

CONCLUSIONS

1. Thorotrast is of practical use in the diagnosis of traumatism of the liver and spleen when the physical signs are obscured by any cause whatsoever.

2. Thorotrast apparently exercises no deleterious effects, even when administered to patients having overwhelming infections.

3. Thorotrast may be administered intravenously immediately upon suspicion of intra-abdominal hemorrhage.

4. Thorotrast is not contra-indicated in injuries involving the liver and spleen.

5. One-half the usual dose was sufficient to produce a shadow heavy enough for diagnosis and a film may be taken four hours after such injection.

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CASE REPORTS AND NEW DEVICES

ADVANCED OSSEOUS SYPHILIS IN A FOUR-MONTHS-OLD INFANT

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Roentgenographic examination of the skeletal system in early infancy is of paramount importance whenever there are clinical manifestations suggesting osseous involvement. The necessity of such a procedure is well illustrated in the case of a four-months-old infant in whom roentgenographic examination revealed advanced and widespread syphilitic osseous lesions in the presence of few other manifestations of the disease. An idea of the frequency of syphilitic osseous lesions in fetal life may be gained from Shipley's (1) studies. He noted advanced syphilitic osseous lesions in 15 of 100 fetuses listed as normal in the catalogue of the Carnegie Institute of Embryology.

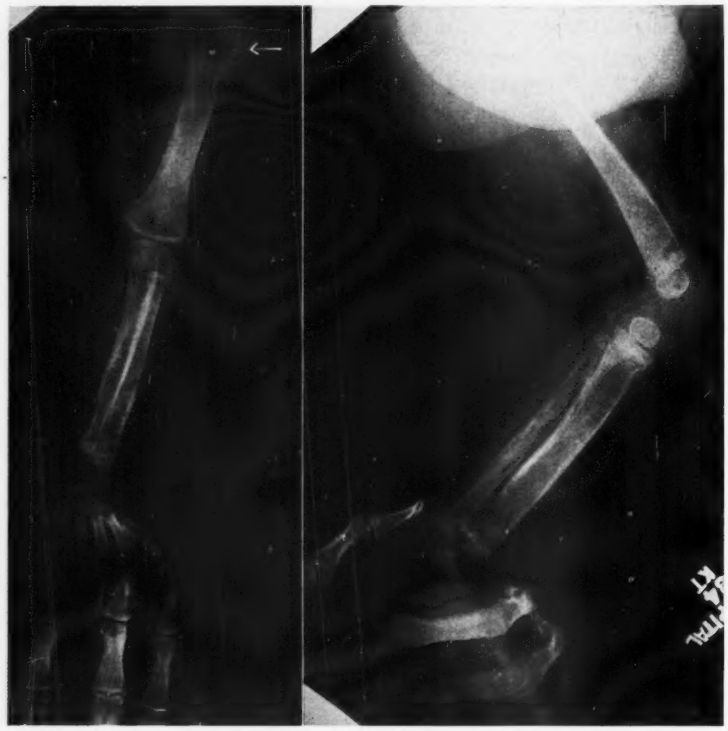

Fig. 1 *(left)*. Showing pathologic fracture in proximal third of left humerus, with marked increased density of the distal ends of the radius and ulna and irregular areas of rarefaction in the distal halves of the radius and ulna.
Fig. 2 *(right)*. Showing destructive bone changes in tibia and fibula produced by congenital osseous syphilis.

A female infant 4½ months old was admitted to the New Haven Hospital on July 8, 1931, with the diagnosis of birth injury to the left brachial plexus and paralysis of the corresponding arm. The mother was a pri-

mipara. The child was born on Feb. 18, 1931, full term, and delivered spontaneously, weighing 3.8 kilograms. During the first two months breast feedings were given; from then on she received complementary feedings along with the breast feeding. In April, 1931, the mother noted that the child cried more than usual when she was handled or fed. She was seen by a number of physicians and was finally referred to the hospital.

On admission the child appeared well developed and nourished, weighing 6.1 kilograms. The infant did not appear acutely ill but was very irritable. Her temperature was 38.1° Centigrade. Tenderness was noted over all the extremities. The reflexes in the lower extremities appeared normal; no satisfactory examination could be made of the reflexes of the upper extremities. The left arm moved clumsily and not as freely as the right. The left deltoid muscle seemed weaker than the right but no difference was noted in the size. The head was well shaped. The anterior fontanelle admitted two finger tips. The eyes were normal and reacted to light promptly. The ears appeared normal. There was no discharge from the nose and no obstruction. Nothing unusual was noted about the lips or in the mouth. The chest, heart and lungs, abdomen, and external genitalia appeared normal. There were no skin lesions present and no palpable lymph nodes. The routine examination of the blood, urine, and spinal fluid revealed nothing unusual. The Kahn and Wassermann tests of the blood were both positive.

Roentgenographic examination of the extremities on July 12, 1931, revealed the following: Dense broad zones at the diaphyseal epiphyseal junctions of the long bones of the extremities; a moth-eaten appearance centrally, with an intact slightly dense periphery of the centers of ossification in the distal epiphyses of the femurs and the proximal ends of the tibias; punched-out areas in the proximal inner aspects of both tibias, with destruction of the contiguous cortex; thickening of the periosteum of the shafts of the femurs and humeri, with irregular areas of bone destruction in the proximal and distal thirds of all the long bones; a pathologic fracture in the proximal third of the left humerus, with no displacement of the fragments (Figs. 1 and 2). In the skull there were irregular moth-eaten rarefied areas scattered throughout the frontal, parietal, and occipital bones, involving both the inner and outer tables (Fig. 3).

Fig. 3. A lateral view of the skull showing the moth-eaten areas of rarefaction in the cranial bones which are characteristic of syphilitic osteitis.

On the basis of these roentgenographic findings a diagnosis of congenital generalized syphilitic osteomyelitis, osteitis, and periostitis was made.

Subsequent serologic study showed a positive Wassermann reaction of the mother's blood and a negative reaction of the father's.

Mercury inunctions were started on July 15, 1931, but were not given regularly because of diarrhea. The antisyphilitic treatment was discontinued on Aug. 5, 1931, when the infant was removed from the hospital against advice. The mother herself refused treatment and, not believing that the child had syphilis, refused further treatment for it. The infant continued to have attacks of recurrent diarrhea, gradually lost weight, and died on Sept. 1, 1931. A necropsy was not obtained.

COMMENT

Osteitis and gummatous periostitis of the skull is fairly common in acquired syphilis

but quite rare in the congenital form of this disease. A recent review of the literature mentions but one case occurring in an infant 11 months old (2). Pathologic fractures of the long bones in congenital syphilis are a great rarity. McLean (3 and 4) in his extensive review mentions only one infant in his own series. He states, however, that such fractures have been described previously in the French literature. Epiphyseal separations have been seen frequently in congenital syphilis and were regarded by some as true fractures. In the case presented there were multiple epiphyseal separations and, in addition, a true fracture of the shaft of the left humerus. Pseudoparalysis of an extremity following syphilitic epiphyseal separations was described as early in 1853 by Bednar (5), of Vienna, and later also by Parrott. It is of interest in this connection that in the case described pseudoparalysis was present only on the side of the fractured humerus. It is also remarkable that although there were advanced skeletal lesions there were practically no other clinical manifestations suggesting the syphilitic nature of the disease.

The antisyphilitic treatment, meager as it was, resulted in definite roentgenographic evidence of healing in the osseous lesions (Fig. 4), namely: lessening of the density in the zones of temporary calcification at the distal ends and slight filling in of the rarefied areas of the diaphyseal ends of the long bones, and also commencing new bone formation about the site of the pathologic fracture (Fig. 5).

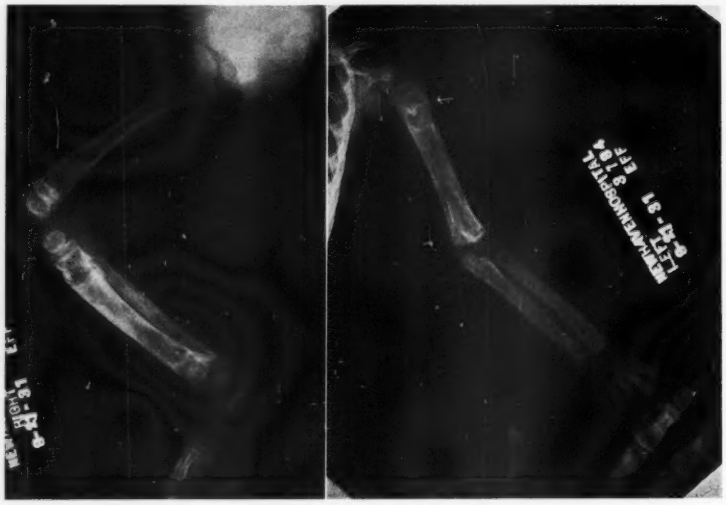

Fig. 4 *(left)*. Demonstrating beginning healing of osseous lesions following mercury inunctions.
Fig. 5 *(right)*. Showing healing of osseous lesions and of pathologic fracture in humerus.

SUMMARY

A case is reported of generalized congenital syphilitic osteomyelitis, osteitis, and periostitis in a four-months-old infant who showed practically no other clinical manifestations suggesting the syphilitic nature of the disease.

Peculiar features were: extensive involvement of the skull, and a pathologic fracture of the shaft of the left humerus.

The importance of the roentgenologic examination of the skeletal system of in-

fants suspected of congenital syphilis is emphasized.

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A CASE OF CONGENITAL ATRESIA OF THE UPPER END OF THE ESOPHAGUS, WITH TRACHEO-ESOPHAGEAL FISTULA

By GEORGE S. REITTER, M.D., EAST ORANGE, NEW JERSEY

Case Report.—The patient was a male infant, white, weighing 5 pounds 5 ounces, born March 4, 1931. He was a first child, born at full term, and delivery was normal. During the first 48 hours, a frothy bloody mucus came from the mouth and nares, and many coarse râles were heard over the chest. The temperature was normal. The infant was not taking fluids well and attempts to feed him seemed useless. He became cyanotic at times and a slight jaundice of the cornea appeared. Urine and meconium were passed freely. On the third day the possibility of an obstruction in the esophagus was suspected and the patient was sent to the x-ray department for examination.

Roentgen-Ray Findings.—A small soft rubber catheter was passed through the nose and a small amount of a thin barium-milk mixture was introduced through it.

Films were taken before the barium was introduced, which showed an aspiration pneumonia in both upper lobes and some dilatation in the region of the esophagus, down to the level of the third dorsal vertebra, the shadow of which proved to be the level of a tracheo-esophageal fistula. A second set of films was taken after the barium, showing that it had reached the level of the third dorsal vertebra and a small amount had been aspirated into the lungs. A third set of films was taken at the end of 15 minutes, showing that further aspiration of the barium had occurred. In the last two films a small amount of barium was seen to have passed into the stomach. A diagnosis of congenital atresia in the upper third of the esophagus, with a tracheo-esophageal fistula, was made. The lower two-thirds of the esophagus was normal.

Subsequent Course.—As soon as the diagnosis was established, the question of operative interference was considered. On account of the poor condition of the infant and the 100 per cent mortality of these operations, surgery was not attempted. Death occurred from inanition and aspiration pneumonia on March 13.

An autopsy was secured and Dr. Arthur R. Abel's findings were as follows:

"The trachea divides at the usual level into bronchi of normal size and conformation; about 12 cm. above the bifurcation, the esophagus enters the trachea through its posterior wall. The esophagus up to the point of union with the trachea appears to be normal in size: above the opening of the esophagus into the trachea, the former is represented by a thin solid strand of tissue extending up the posterior wall of the trachea to the level of the cricoid cartilage. Here it joins a small blind sac which is closely applied to the larynx posteriorly and represents the upper portion of the esophagus.

"The larynx has a normal conformation. Both lungs show areas of bronchopneumonia, especially the right lower lobe. The heart is normal in size and conformation, there being no evidences of a persistent ductus arteriosis. The remaining organs are normal in every respect."

On March 13 further examination of the lungs was made after autopsy. A catheter was passed through the esophagus from below upward and a small amount of lipiodol was injected. In these films the esophagus below the tracheo-esophageal fistula was seen to be entirely intact and the junction of the esophagus and trachea was well defined. The barium which had been aspirated into the bronchial trees of both lungs in the previous examinations had been expelled.

Embryologic Considerations.—The esophagus, trachea, and larynx are developed as an outgrowth from the entoderm alimentary canal. The first step in the development of the pulmonary system is a pouching of the ventral wall of the esophagus throughout its entire length. This ventral wall or groove deepens until its edges finally meet and fuse. In this manner, the groove becomes a tube which is separated from the esophagus, beginning at the gastric end and extending towards the pharynx. This separation is not complete, however, until a bifurcation takes place, which is the pulmonary portion below. The tube above does not as yet separate. At first the evagination consists of entoderm, but, later, fuses with mesoderm. The epithelial lining in the air passages springs from entoderm, while the basic structures spring from mesoderm. The trachea is the elongated stalk of the pulmonary system. At an early period two dorsoventral ridges appear at the junction of the trachea with the esophagus. According to Kreuter (1), Krauss (2), and Mall (3), interference of mesoderm with entoderm at this site would explain these abnormalities.

Congenital malformations of the esophagus have been classified by Whipham and Fagge (4), as follows:

(A) Congenital absence of the entire esophagus; a very rare condition.

(B) Bifurcation of the esophagus with junction of the two portions near the lower end; only one case reported.

(C-1) Congenital atresia in which the esophagus is divided into two parts; a type most commonly found. The upper end terminates blindly in a cul-de-sac. The lower end opens above into the trachea or one of the bronchi, and below in a normal manner into the stomach. The two segments are connected by a fibrous or muscular cord. *(C-2)* Much more rarely there is no opening of the lower part into the air passages, the two blind ends merely being joined by a fibrous band.

(D) Stricture caused by a fold of the mucous membrane projecting into the lumen of the tube like a diaphragm (1) at the upper part of the esophagus immediately below the pharynx or (2) near the lower end.

(E) Congenital stenosis of the lower end of the esophagus.

The case reported above belongs, therefore, to Group *C*-1.

A survey of the literature up to March, 1930, reveals that 232 cases of congenital atresia of the esophagus have been recorded, which makes my case number 233. In about 70 per cent of the specimens, the upper portion of the esophagus ended in a more or less dilated cul-de-sac and the lower portion in the stomach normally. The tracheal fistulas occurred in the region of the bifurcation of the main bronchi, a few of them of the rarer types. Other abnormalities were also noted in the same individuals: *viz.*, double uteri, deformities of the phalanges, atresia of the anus, an anomalous

right subclavian aorta arising from the descending aorta, deformities of the right hand, thirteen ribs, and abnormalities of the heart.

In the earlier cases, the diagnosis was not made until autopsy, while in most of the later ones the clinical findings have suggested the possibility of lesions in the esophagus. Upon submitting the patient to x-ray examination, the diagnosis is easily established.

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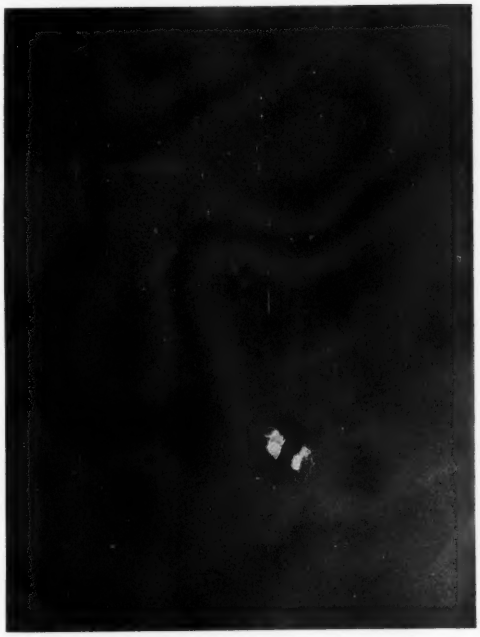

Fig. 1. Lateral view before delivery.

PRE-DELIVERY ROENTGEN DIAGNOSIS OF ANENCEPHALY: CASE REPORT

By SAMUEL BRUCK, M.D., PHILADELPHIA
Roentgenologist to Jewish, Northeastern, and Northern Liberties Hospitals, Philadelphia

In writing on "The Early Recognition of Anencephaly," Dr. W. O. Weiskotten[1] states that since 1917 only 18 cases have been reported as having been diagnosed by the roentgen ray before delivery. I would like to add one more case.

L. K., aged 21, primipara, admitted to Jewish Hospital on Feb. 22, 1932, in labor at term. Physical examination showed abdomen to be very large for date of pregnancy. Fetal sounds unobtainable. Back of fetus appeared to be to the maternal right side. There was marked bulging of the upper portion of the uterus. Provisional diagnosis by the obstetrician was twins or hydramnios. The attending obstetrician could not quite determine what the condition was, but he thought he was probably dealing with an obstructive labor and was considering

Fig. 2. Anteroposterior view of still-born monster after delivery.

[1]RADIOLOGY, January, 1933, XX, 58.

Fig. 3. Lateral view of still-born monster after delivery.

Cæsarean section. With the hope that the x-ray might help to reveal the abnormality, immediate examination was ordered.

The roentgen report was as follows: "The skeleton of a fetus is seen in the abdomen, back anteriorly and to the right and the head as the presenting part. The presenting part is very small, not developed. The lower jaw bones are clearly outlined but the upper portion of the skull is apparently either missing to a great extent or very poorly developed. The entire fetus is small for a term pregnancy.

"*Conclusions.*—There is a monstrosity with under-developed or maldeveloped head. The fetus is probably not alive. The labor is not an obstructive one."

In view of this report the obstetrician decided to wait and the woman delivered herself spontaneously of a still-born monstrosity.

An x-ray examination of the fetus revealed the following: "The bones of the head show only a normal lower and upper jaw. No evidence of any teeth can be seen in either jaw. Practically all of the bones of the skull are missing. The ribs are normal. The bones of the pelvis and of the upper and lower extremities are well formed and normal. The bones of the shoulder girdles are normal. The bones of the fetus show no changes suggesting congenital syphilis."

I am adding this as another case diagnosed before delivery. Had it not been for the roentgen examination, this patient would have been subjected to an entirely unnecessary Cæsarean section.

EDITORIAL

LEON J. MENVILLE, M.D. . . . *Editor*
BUNDY ALLEN, M.D. . . *Associate Editor*

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FALSE ROENTGENOLOGIC ECONOMY

For several years manufacturers have been placing on the market different kinds of sensitive x-ray paper, to be used in the place of x-ray films, with emphasis on their economical value. From the reports we have received, besides our own experience, we doubt whether this sort of paper, as now made, can replace celluloid films in roentgenographic examinations. However, there can be but little doubt that such paper may serve usefully in certain types of roentgenographic examination; for instance, to determine whether a fracture remains in good position after having been set. We do not believe that its use is practical for all types of x-ray examinations, in spite of the enthusiastic reports from salesmen. It has not the speed of films, is non-transparent, unwieldy to handle, and, most important of all, it fails to bring out fine details such as x-ray films are capable of showing. In certain types of roentgenographic examination, if it is relied upon exclusively, harm may result. This is particularly true in the diagnosis of early pulmonary tuberculosis. Many such cases may easily escape the vigilant eye of the experienced roentgenologist, whereas the same roentgenologist, with dependable films, would readily observe the tuberculous lesion.

The indiscriminate use of sensitive paper in the diagnosis of early pulmonary tuberculosis in children is being advocated by a certain tuberculosis organization of repute, as an economical procedure, making it possible to examine wholesale, large groups of children by means of the x-ray. This apparent disregard for efficient and accurate roentgenographic examination of children's chests, by substituting sensitive paper for x-ray films as used the world over, is a deplorable condition and should be frowned upon by the radiological profession.

Our attention has been called to a booklet published recently by the National Tuberculosis Association, entitled, "Procedure for the Discovery and Cure of Tuberculous Children." In it we find pertinent matter relating to the importance of searching for tuberculosis among apparently healthy children, utilizing several methods of examination, including the roentgen ray. It also emphasizes the necessity for searching the families of these children for carriers of tuberculosis. These objectives are most commendable and will meet with widespread approval by the radiologists of this country, and we are certain that the National Tuberculosis Association may count on our co-operation for the consummation of its lofty ideals. However, but few radiologists will agree with the following report of their Committee on Protective Care for Tuberculous Children, found in the Association's booklet (pages 4 and 5).

"In rural areas the portable x-ray apparatus is a boon. It is not as perfect as the standard equipment, but entirely adequate for making routine chest pictures of children.

. . . . . .

"A new paper film is now marketed, which seems to open up possibilities of x-raying more children, because of its low cost. The paper film is available in both sin-

gle sheets and roll form. The single sheets may be used in regular cassettes with technic similar to that for celluloid films. The efficiency of the films has been checked, with the conclusion that, although the celluloid film is superior for showing shadows of fine detail, the paper films are entirely adequate for routine clinic work and for diagnostic surveys. A further development in the use of paper films has come about through the devising of a series of co-ordinated units of procedure—typing of identification data on a lead-backed card to be photographed directly on the film; taking of exposures in rapid succession by means of a specially designed camera; development of the film in roll form; reading of the film, still in roll form, on a specially designed viewing cabinet. This permits taking of x-rays for the survey of groups, such as school children, at the rate of 150 per hour, and it is possible to read and file the films much more rapidly than before. The cost varies with the number x-rayed, being 75 cents per x-ray if 500 or more subjects are supplied each day. The machine is transportable and the company includes in the price of the x-ray the following service—setting up the machine, two competent technicians to operate it, an electric typewriter and typist, developing of the rolls of film, and their return to the organization conducting the project. The viewing cabinet may be rented for a nominal sum. This rapid survey method has been successfully used by several organizations. The Powers X-ray Products, Inc., will give full particulars about this method."

One of the most unfortunate features of the recommendation of the National Tuberculosis Association is the advertisement of commercialized medicine. While the writer has no cause to question the good faith of the firm mentioned, yet he doubts the wisdom of the Association's statement that the company "will give full particulars about this method," and, further, "the efficiency of the films has been checked and is entirely adequate." A physician skilled in reading roentgen films is the only one who can safely make the latter statement—certainly not a manufacturing company.

The Committee admits that celluloid x-ray films are superior for showing shadows of fine detail, but they believe that sensitive paper is "entirely adequate for routine clinic work and for diagnostic surveys." This is a strongly inconsistent statement, for in one breath they admit that sensitized paper will not produce as fine detail as x-ray film (an indispensable factor for the early recognition of early tuberculosis), and in the next state that the paper is entitrely adequate for a diagnostic survey. This is an admission of economy in conflict with accuracy. It is not inconceivable that, with such dilatory methods, many cases of childhood tuberculosis will escape detection, defeating the very purpose for which the Association exists, namely, the control of childhood tuberculosis.

Some may say that this type of roentgenographic examination is better than no examination, for such a survey would not be possible by employing dependable, but costly, x-ray films. In answer to this we would say that any enterprise undertaken to examine the human body should never be so derelict in its obligation as to permit any but the very best that is possible to give. There is nothing more tragic in medicine than to give a patient false security resulting from an inaccurate examination. It would, perhaps, be a better plan to examine fewer children at a time, but have them examined thoroughly with proper equipment and material by a competent radiologist. The survey would no doubt be prolonged, but the safety assured would be sufficient recompense for the slight loss of time and the added expenditure.

No medical question is more in dispute than the interpretation of children's x-ray films of the chest. Radiologists all over the

world recognize the fact that it requires the ingenuity of an expert to make a correct interpretation of early pulmonary tuberculosis in a child, even when using powerful apparatus and the very best x-ray films. The National Tuberculosis Association also recommends the use of a portable x-ray apparatus in its tuberculosis survey. We wonder how instantaneous exposures are possible with such inadequate apparatus. There is no greater need for fast exposure than in the examination of children's chests. This is especially true when examining restless and crying children, and this, we know by experience, occurs not infrequently. Also, there are times when an oblique film and also stereoscopic examination are necessary to arrive at a definite diagnosis; in such instances the patient must be deprived of these important agencies, since they can scarcely be done with sensitized paper.

It is unfortunate that such a well-known national organization as National Tuberculosis Association will, in its enthusiasm, permit economy to compete with accuracy when human lives are at stake. It fails to appreciate that it is helping to destroy the very foundation of its organization.

We should not be oblivious of our obligation and responsibility to the children, and we should never hesitate about giving them the benefit of the knowledge and experience of modern medicine.

A continuation of such practices as using inadequate apparatus and material in the tuberculosis survey of children must eventually result in preventing any further progress of the use of the roentgen ray in the early diagnosis of tuberculosis in children.

If the radiologists of the country would write the National Tuberculosis Association expressing their opinion on this subject, we feel confident that this organization, for which we have much admiration and respect, will see the wisdom of changing its present attitude, which indicates indifference to an accurate examination, to one of insistence upon exactness, by utilizing proper and adequate roentgenologic facilities.

PRESIDENTIAL GREETINGS

There is not a day in one's life but he has cause to show his gratitude for help received, for encouragement along the way, for loyal friends, and sometimes for honors heaped upon him. Truly I have just cause to return my thanks for the many gracious and tangible expressions of real assistance and the inspiration given me by my fellow-members of this Society, and especially for the confidence reposed in me by bestowing the highest honor in their power to give.

May I, then, be privileged to take advantage of this festive season to return my heartfelt thanks to every member, and to most sincerely wish that each one will receive the richest blessings at this Christmas time. I wish for each the best that can be given, and I pray that the New Year shall indeed prove to be a happy time, full of glorious opportunities and achievements.

For myself, I look upon the New Year as a further challenge for real altruistic service. This great continent, along with all the world, has been going through the melting pot. What will be the result? Shall we come out refined and pure? Will the dross of selfishness and greed be eliminated? Alas, we know too truly that all the world will not be purged, but will we not give such an example of devotion to the high calling of our profession that we will contribute in a large measure to the amelioration of all the sufferings of humanity?

There is more than bodily sickness and infirmity to be cured. Hearts are burdened, spirits are depressed, difficulties are many, perplexities are great. But there is a glow on the horizon, there is a sign of a brighter day. Let us have faith, and steadfastly do our part by instilling confidence in place of doubt, happiness for despair, peace for dis-

quietude. This can be brought to pass if the high ideals of hearty co-operation, as expressed at our recent conference, are put into actual practice by each one of us.

The true message of Christmas is "giving" not "receiving"—"'Tis more blessed to give than to receive." May we then be prepared, every day in the coming year, to give our very best in time and thought and deed to spread the cheer for which this world waits? Let us put into action that which oftentimes is but abstract and platitudinous when we say "A Merry Christmas."

With all my heart I wish you the happiest of times, and my sincerest wishes are extended not only to the members and their staffs but also to their families and friends.

And if, perchance, we do not receive, in turn, the just recognition of our sacrifices, let us be mindful that some day, somewhere, we shall do so.

> Others, I doubt not, if not we,
> The issue of our toils shall see;
> And, we forgotten and unknown,
> Young children gather as their own
> The harvest that the dead have sown.

May a gracious, wise Providence bestow on you all that is needful both for yourself and others, and again, may I wish you a truly Happy Christmas and a Prosperous New Year.

W. Herbert McGuffin, M.D.

COMMUNICATION

MINNESOTA RADIOLOGICAL SOCIETY

The Minnesota Radiological Society held its Fall meeting at the St. Paul Athletic Club, St. Paul, Minnesota, Nov. 11, 1933. The following program was presented:

1. Osteochondritis Juvenilis Deformans (Perthes' Disease): Report of Cases. W. L. Burnap, M.D., Fergus Falls.

2. Observations from a Clinical Tour. M. A. Shillington, M.D., St. Paul.

3. Pneumonia in Young Infants Associated with the Aspiration of Various Oils. Kano Ikeda, M.D., St. Paul.

4. The Roentgen Diagnosis of Placenta Prævia. Walter H. Ude, M.D., Minneapolis.

5. The Improvement of Chest Radiography. R. B. Wilsey, M.A., Rochester, New York.

6. Motion Picture Demonstrating Manufacture of X-ray Film. L. A. Carlson, St. Paul.

7. The American Registry of Radiological Technicians. George M. Landau, M.D., Chicago, Illinois.

Address: The Value of Ventriculography and Encephalography to the Brain Surgeon. Alfred W. Adson, M.D., Rochester, Minnesota.

BOOK REVIEWS

Amerika und die Medizin. By Henry E. Sigerist, M.D., Professor in Johns Hopkins University, Baltimore. A volume of 352 pages, 30 illustrations, 2 maps. Published by G. Thieme, Leipzig, Germany, 1933. Price, 9.60 marks.

In his eloquent preface the author explains that, in view of his engagement at Johns Hopkins, and while still at the University of Leipzig he began this book, in order that he might write as an alien spectator before entering on the practice of his profession in America. It is addressed not only to Europeans who have but a vague idea of the New World and its physicians, but also to American readers who may be interested in the impressions of a European who has taken pains to learn something about the medical history of the nation into which he is to be adopted. Medical science, he repeats, knows no national boundaries. Padua produced Vesalius, gave Harvey stimulus, and was finally the home of Morgagni. After 1700, Leyden, with Boerhaave, was the high school of medicine. Then followed Scotland, England, France, Austria,

and Germany. Almost all the European states have had their opportunity. To the historian it appears that America's hour now has struck. Why? That the author tells in an orderly and interesting narrative.

With an historical sketch of primitive America and its Indian medicine for a background, Sigerist swiftly paints a panorama of American medicine beginning with Giles Heale, the surgeon of the *Mayflower,* Wilkinson, Wotton, and Russell of the Virginia colonies, and Thomas Bond, who established the Pennsylvania Hospital. Then came John Morgan, Benjamin Rush, Ephraim McDowell, Drake, Beaumont, Gross, Sims, Holmes, Mitchell, Billings, Osler, and Welch. Among institutions receiving due attention are the Johns Hopkins Hospital and School of Medicine, New York Hospital and Cornell Medical School, Columbia-Presbyterian Medical Center in New York, Mayo Clinic, Massachusetts General Hospital, and the Rockefeller Institutes. All American physicians who can read German and who would like to look at American medicine, especially in its historical aspects, through the eyes of a friendly foreigner, will be entertained by this volume.

RECENT ADVANCES IN RADIUM. By W. ROY WARD, M.B., B.S., M.R.C.S., Medical Director and Surgeon to the Radium Institute, London, and A. J. DURDEN SMITH, M.B., B.S., M.R.C.S., Surgeon to the Radium Institute, London. A volume of 324 pages, with 4 colored plates and 140 black-and-white illustrations; cloth. P. Blakiston's Son and Co., Inc., Philadelphia. Price, $5.00.

The radium therapist will find this book to be most helpful, a distinct aid in solving his therapeutic problems and a source of ready reference. It contains much valuable material, well organized and comprehensively arranged. Further, it should have a wide appeal, especially to the student of therapeutic radiology, to the surgeon and clinician; in fact, to any physician interested in the management and care of patients with radiosensitive malignant and non-malignant conditions.

It covers most fully the advances made in this novel field of therapy, retaining sufficient historical background to make clear the importance of mastering the art and science of radium therapy. The field of the roentgenologist is also well presented, demonstrating the close relationship between the two methods of treatment. Where reliable statistics are available the results of surgery and irradiation therapy are compared.

The authors stress the important fact that radium is efficient and should find a place in the armamentarium of the surgeon. Further, it is well established that surgery is a useful adjunct to radium therapy. Though these procedures may be employed alone, much better results will be obtained when the surgeon and radiologist co-operate most fully in order to plan for the maximal benefit to be had in the case under consideration. Individual management will always give the best result.

The technic as employed at the Radium Institute, London, is clearly presented, with statistics of malignant disease as it occurs in England, together with methods and opinions of other recognized Continental and American clinics as well as of independent workers who are employing standardized technic. The method is presented in three parts. Part I is divided into eight chapters, presenting the general considerations, physics, action of radiation, radiosensitivity, dosage, radium apparatus, protective measures, and mass radiation. The main part (Part II) deals entirely with malignant disease and contains ten chapters dealing with carcinoma of the breast, uterus, tongue, lip, cheek, palate, tonsil, lower jaw, upper jaw, antrum, larynx, pharynx, esophagus, rectum, anus, skin, penis, vulva, bladder, prostate gland, and eye. Part III deals with non-malignant conditions—papilloma, hyperkeratosis, keloids, lupus, angioma, tuberculous adenitis, leukemia, lymphadenoma, and uterine hemorrhage. The subject matter for each part shows careful selection and readily emphasizes the improvement and progress made in that particular branch of irradiation therapy.

Dr. Ward and Dr. Smith have written this

book in an unusually easy-to-read and instructive style. The physician who is approaching the subject for the first time and the experienced irradiation therapist alike will find this volume to be a cherished addition to his library, for it can not fail to give the reader a better understanding and lead to wider interest in radium therapy.

ANNOUNCEMENT

Beginning January, 1934, the Radiological Society of North America will furnish six free cuts for each illustrated paper read before the American Congress of Radiology, in Chicago, Sept. 25-30, 1933; also for such papers as shall be contributed and accepted by the Editor after Jan. 1, 1934. It is appreciated that this will be welcome news to the authors who contribute to RADIOLOGY, and it gives sincere pleasure to the Editor and officers to be able to make this announcement. During the period of financial hardship our contributors have, almost to a man, loyally borne the expense of their own illustrations, thus helping the Society to keep its Journal functioning, as it could not have done without their aid.

As to reprints, the Society desires to announce that it will furnish upon request 50 reprints free (without covers or envelopes) to authors of papers either read before the Congress or accepted for publication after Jan. 1, 1934. The Society is unable to extend these free features to papers read before previous annual meetings or sent as contributions previous to the above-mentioned date. Cuts in excess of 6 and reprints in excess of 50 will be billed to the author.

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